AGRICULTURAL ENGINEERING

AUGUST • 1953

In this Issue . . .

Some Engineering Design Factors for Hill-Drop Cotton Planters

Effect of Traffic Soles on Conservation and Production in Agriculture

Frequency of Irrigation as a Factor in Sprinkler Irrigation Design

Measuring Dynamic Forces in Tractor Linkage for Mounted Implements

Effect of Soil-Aggregating Chemicals on Physical Properties of Soils

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When Does 1=4?

NEW CASE EDUCATIONAL MOVIE

Shows You!

Here is a four-way teaching impact! New movie with companion poster, study guide, and take-home booklet tell farmers and farm youth how to make *one* acre of renovated pasture pour out all the meat, milk, wool, and cash that four unimproved acres now produce. This new quartet of Case educational materials shows how to test and treat soils—renovate old sod—establish rich new growth—how to use for immediate and long-time high income. The movie is entitled "One Equals Four," and like all Case educational movies is 16 mm., in full color and sound. Non-commercial; runs 22 minutes. Film is loaned, printed matter furnished without charge to teachers, agricultural leaders, farm and civic clubs, other responsible persons and groups. Film loans should be requested as far ahead as possible, and alternate date specified if feasible.

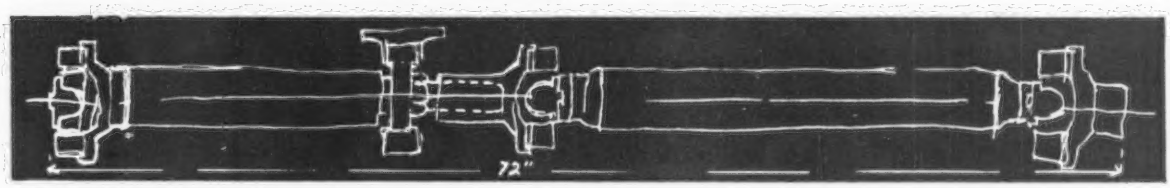
60 EDUCATIONAL HELPS

As its contribution to a prosperous, enduring agriculture, the Case Company has prepared some sixty educational items all free to users. These include motion pictures, sound slide films, posters, study guides, booklets, and charts on a long list of subjects on conservation and other profitable farming practices. Be sure you have the latest Case visual education materials catalog, "Visual Aids to Modern Farming." It describes each item and tells how to order. Be sure to get your catalog and all materials through your nearest Case dealer or branch house. J. I. Case Co., Racine, Wis.

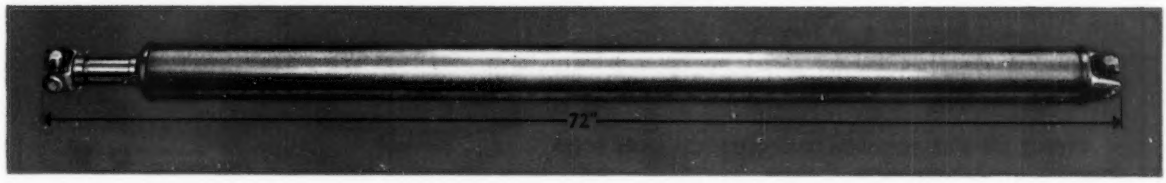
CASE

You CAN Maintain BALANCE in a LONG Truck Propeller SHAFT

If there is a reason why *your* truck should not have a *mid-ship bearing,* to support an extra long drive line, like this —



You can eliminate the mid-ship bearing — and one universal joint — by using MECHANICS Roller Bearing UNIVERSAL JOINTS and a specially balanced, *extra long* PROPELLER SHAFT like this —



MECHANICS engineers constantly are solving joint and propeller shaft problems. Let them contribute their extensive experience toward making *your* truck or heavy duty equipment *drive lines* more effective.

MECHANICS UNIVERSAL JOINT DIVISION
Borg-Warner • 2046 Harrison Avenue, Rockford, Illinois

MECHANICS
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UNIVERSAL JOINTS

For Cars • Trucks • Tractors • Farm Implements • Road Machinery • Aircraft • Tanks • Busses and Industrial Equipment

AGRICULTURAL ENGINEERING

Established 1920

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here's how leading manufacturers of business machines get them with NEEDLE BEARINGS

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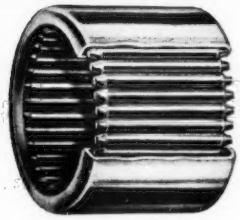
The Torrington Needle Bearing has become "standard equipment" on countless products throughout industry since its introduction nearly twenty years ago. Its small size and infrequent lubrication needs are of great advantage in compact, tightly encased designs.

Perhaps the Needle Bearing can solve your anti-friction problems. Our engineers will be glad to work them out with you.

THE TORRINGTON COMPANY
Torrington, Conn., South Bend 21, Ind.



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Trade-marks of some of the business machine manufacturers whose products enjoy the benefits of Needle Bearings.

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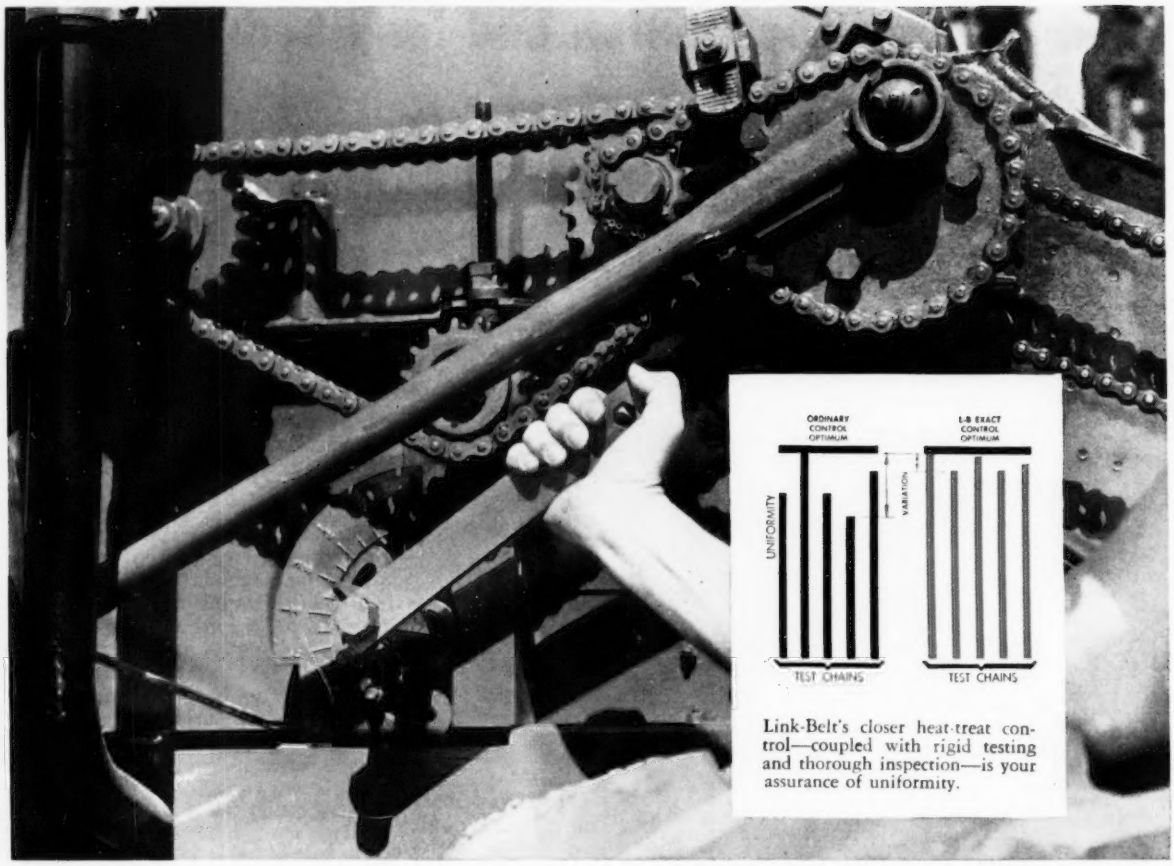

Link-Belt's closer heat-treat control—coupled with rigid testing and thorough inspection—is your assurance of uniformity.

Closer heat treat control means longer roller chain life!

But it's only one of many engineering extras you get from LINK-BELT

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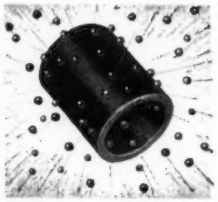
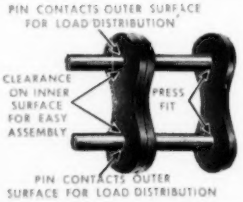
LINK-BELT COMPANY: Plants: Chicago, Indianapolis, Philadelphia, Colmar, Pa., Atlanta, Houston, Minneapolis, San Francisco, Los Angeles, Seattle, Toronto, Springs (South Africa), Sydney (Australia). Sales Offices, Factory Branch Stores and Distributors in Principal Cities. 13.120-B

Don't overlook these other LINK-BELT extras

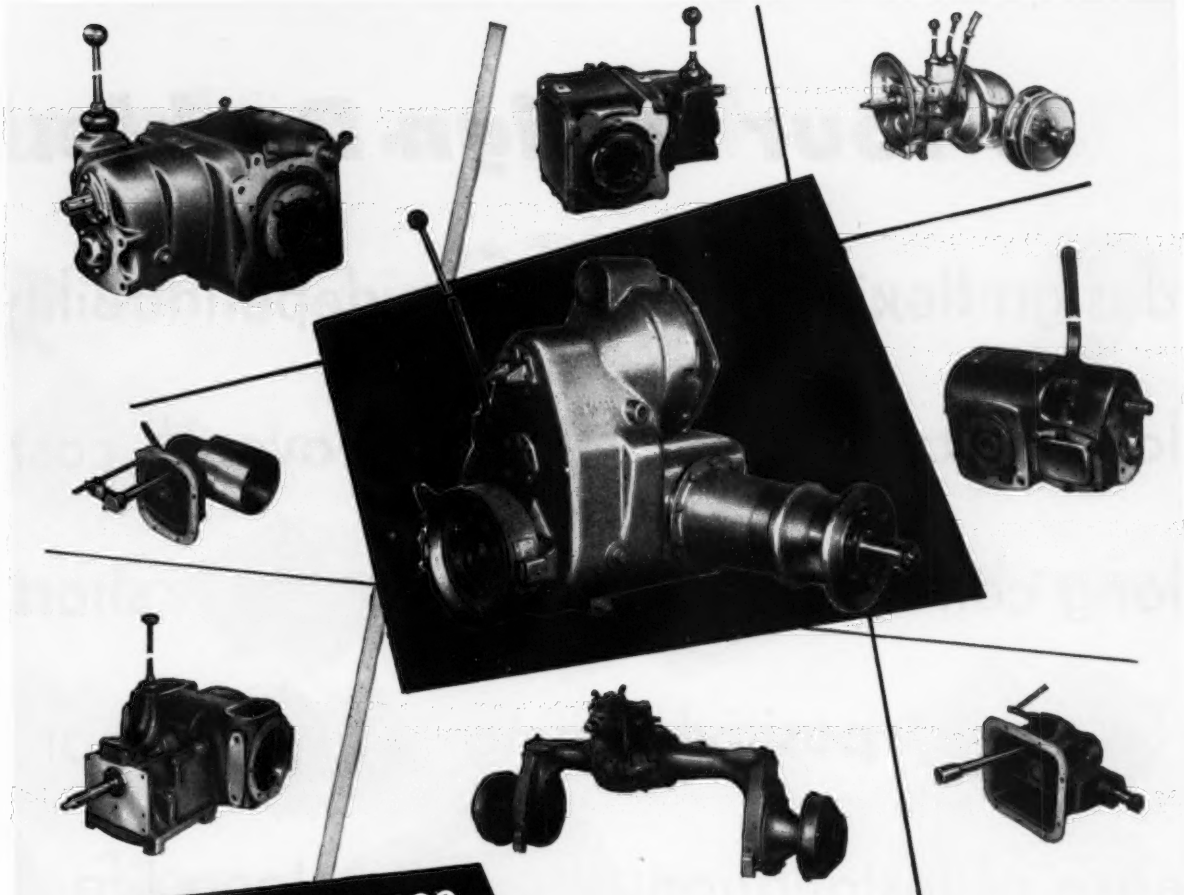


Shot-peened rollers have extra fatigue life for higher speeds, heavier loads.


PIN CONTACTS OUTER SURFACE FOR LOAD DISTRIBUTION
CLEARANCE ON INNER SURFACE FOR EASY ASSEMBLY
PRESS FIT
PIN CONTACTS OUTER SURFACE FOR LOAD DISTRIBUTION

Couple, uncouple multiple-width chains easily.

Lock-type bushings assure free articulation.



performance

The performance of any heavy-duty automotive, farm or road building equipment is largely dependent upon the performance of the mechanism that transmits power from motor to wheels. It is, therefore, easy to see why those manufacturers who insist upon exceptionally high standards of performance leave this all-important job of power transmission to CLARK Drive Units... designed, engineered and built to deliver the utmost in efficiency, economy and dependability. These are the manufacturers who have found that "it's good business to do business with CLARK."

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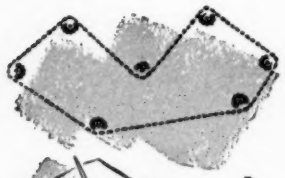
If Your Design Problem

design flexibility

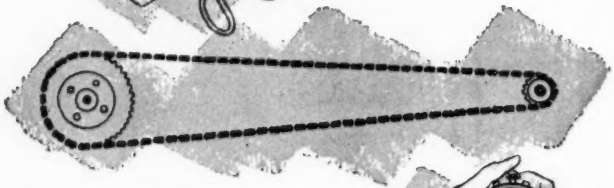


dependability

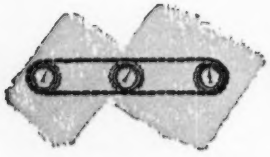
low initial cost

low overall cost

long centers



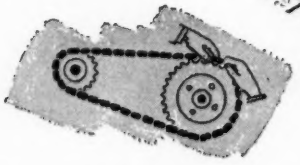
short



positive timing

heat

ease of installation



long life

Chain Is Your Answer

Yes, chain will solve any of these problems in both drive and conveyor service. The important point is to be sure you select the best chain to do the job. That's why so many agricultural machinery designers make their selections from the complete Chain Belt line.

In the complete Chain Belt line there are literally hundreds of sizes and types of chain . . . but only one can be the *best* chain for your particular application. For example: for a high speed drive, Baldwin Rex® Roller Chain is probably most efficient. For where speeds are slower and loads

REX

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moderate, Rex Steel Detachable Chain or Rex Cast Detachable Chain is probably the answer. Where speeds are slow but a finished steel chain desirable, Baldwin-Rex Double Pitch Roller Chain is a likely choice.

Our Rex Field Sales Engineers are specially trained to help you with your chain selection problems. For more help, call your nearest Chain Belt branch office or write to Chain Belt Company, 4680 W. Greenfield Ave., Milwaukee 1, Wisconsin.

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Ring wear REDUCED.....33%

in over-the-road tests with

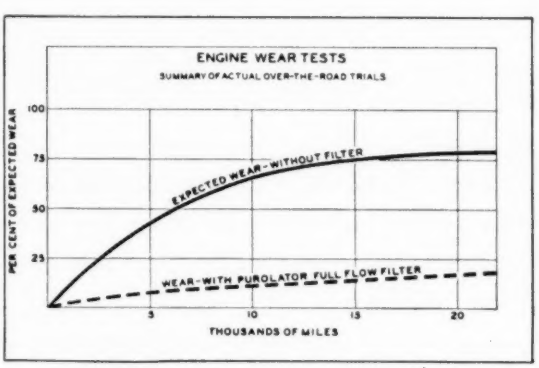
PUROLATOR

FULL-FLOW

MICRONIC FILTERS

In test after test, America's leading automotive and engine manufacturers are proving that Purolator oil filters are the best!

The figures you see above are from engineering records compiled by one of the world's largest makers of passenger cars and trucks. They are the results of gruelling *actual-service* tests made to compare the performance of various makes and types of lube oil filters. And, like so many other important ones, this manufacturer found that Purolator*, *and only Purolator*, oil filters gave them the engine-saving performance they were seeking. They found that Purolator Full-Flow filtration was better by far than *any* partial flow system . . . that the Purolator Micronic* Filter element gave finer filtration, with longer life, at lower pressures than any other tested.



There are sound reasons for the Purolator Micronic Filter Element's outstanding superiority! It is the *only* element capable of delivering full-flow rates during its entire service life, *with dependable filtration down to submicrons* (.0000039 in.)! It has *ten times* the effective filtering area of old-style filters.

If you are a maker or user of internal combustion engines, you are invited to test and *compare* Purolator performance for yourself. Our Engineering Department will gladly co-operate in helping you prove to your own satisfaction *that there is no other oil filter capable of giving you better engine protection than Purolator. Simply write, telling us what equipment you are using.* *Reg. U. S. Pat. Off.

PUROLATOR PRODUCTS, INC.
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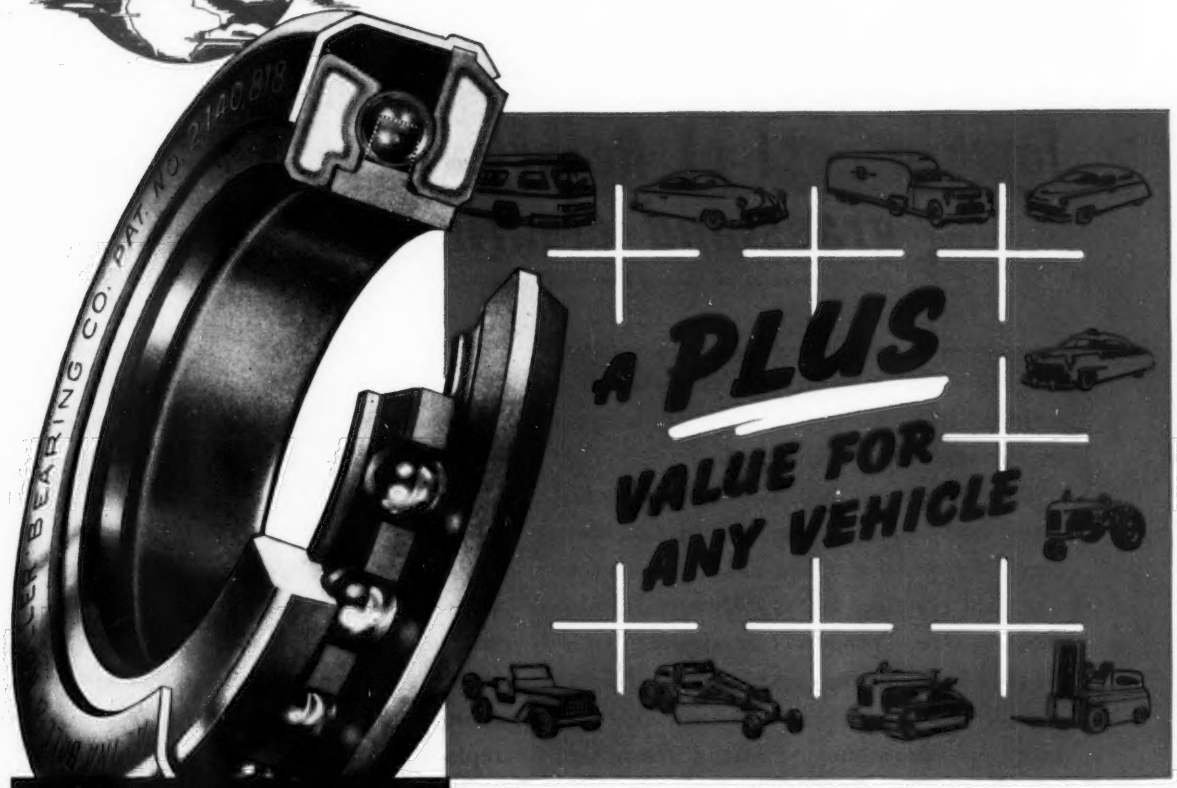
PUROLATOR
MICRONIC OIL FILTER
"FIRST IN THE FIELD OF FILTERING"

THE WORLD-FAMOUS AETNA T-TYPE CLUTCH RELEASE BEARING



Plus VALUE FEATURES

- T-shaped oil-impregnated bronze ball separator maintains perfect concentricity—eliminates eccentric thrust, excessive wear—assures the plus smoothness, quietness and endurance of bronze-to-steel contact.
- Large, factory-packed grease reservoir assures lifetime lubrication—no need for costly grease fittings or oil lines.
- Special construction locks shell to free race, forming leak-proof joint. Lubricant can't escape to clutch facings, never needs replenishment.
- Case hardened races for wear-resistant working surface and tough, elastic, shock-absorbing core.

Standard and Special Ball Thrust Bearings • Angular Contact Ball Bearings • Special Roller Bearings • Ball Retainers • Hardened and Ground Washers • Sleeves • Bushings • Miscellaneous Precision Parts.

In 1953, as in the past 19 years more of the nation's mobile vehicles will be equipped with the Aetna T-Type clutch release bearing than with any other type. Its unrivaled service life has always made it the most economical in the long run. Once installed it is trouble-free, attention-free for vehicle life. Thanks to its design and lubricant capacity there's no need of costly machining operations for oil lines or grease fittings—no need for further maintenance whatsoever. Think what that saves in man and machine hours on the assembly line, in saving up-keep costs for the vehicle owner.

It's a trusty sign of dependability and economical performance in any vehicle—the famous Aetna T-Type bearing. Investigate. Find out the many other sound reasons it deserves a place in your specifications.

AETNA BALL AND ROLLER BEARING COMPANY
4600 Schubert Avenue • Chicago 39, Illinois

Use of Raw Edge V-Belt

improves performance and lowers cost of Rotary Cutter for rugged grassland clearing and mowing

Four raw edge Dayton V-Belts replace *five* wrapped belts and step up drive efficiency in the newest model Roto-Speed.

This versatile machine, manufactured by Lilliston Implement Company, Albany, Ga., operates under the most severe and diversified conditions of grassland farming. Designed to handle every type of project—from clearing underbrush and mowing pastures to shredding cotton and cutting sturdy tobacco stalks and stubble—Roto-Speed drives must withstand tremendous stresses and strains. In every case, Dayton V-Belts hold with bulldog tenacity insuring maximum and continuous cutting power.

More and more manufacturers of agricultural equipment are turning to Dayton V-Belts as a dependable source of low cost V-Belt drive power. Farmers, too, are asking for longer-wearing Dayton original equipment V-Belts through their implement dealer for greater economy and ease of application in V-Belt replacement.

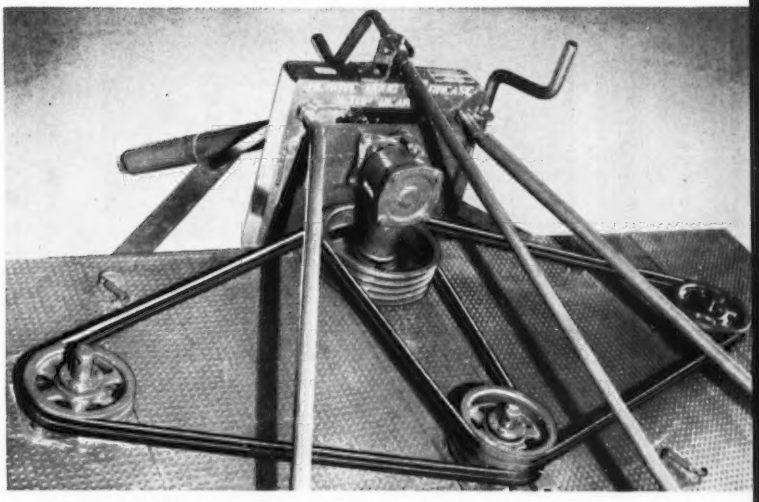
Photos courtesy Lilliston Implement Co.

Above photo shows dense, tangled underbrush before clearing and mowing with the Roto-Speed Cutter. Note height of weed stocks with the man shown in the center of the photo.

Lilliston Roto-Speed Cutter equipped with Dayton raw-edge V-Belts, rapidly transforms dense underbrush into valuable additional acreage for grassland farmer.

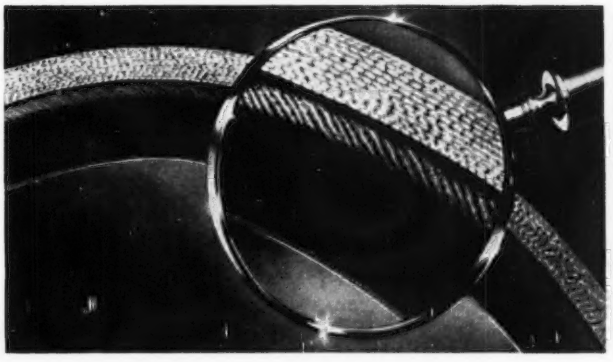
Dayton raw edge V-Belts won the decision

—by producing an even, steady flow of power to all blades regardless of the force of impact to which they were subjected. Repeatedly, the die cut raw edge maintained an unfailing grip on the drive pulleys where ordinary V-Belts would have failed.



What's your drive problem?

—Dayton's sales engineering experts will be glad to assist you in securing the maximum power under all operating conditions. Just write, wire or call Dayton Rubber Company, Agricultural Original Equipment Division, Chicago, Illinois.



Enlarged photo shows die cut raw edge of Dayton V-Belt. Raw edge provides rubber-to-metal contact that maintains a firm hold at all times, thus eliminating drive slippage.

© DR 1953

Dayton Rubber

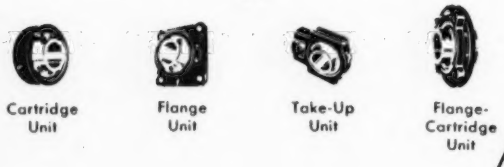
Since 1905

Agricultural Sales Engineers in Chicago, Moline, San Francisco, Cincinnati and St. Louis

Only SEALMASTER Gives You Positive Locking Plus Easy Shaft Mounting

SEALMASTER BEARINGS now provide the first practical answer to positive shaft locking with easy shaft mounting. Just slip the bearing onto the shaft . . . tighten two set screws . . . that's all. This is made possible through ZONE HARDENING.*

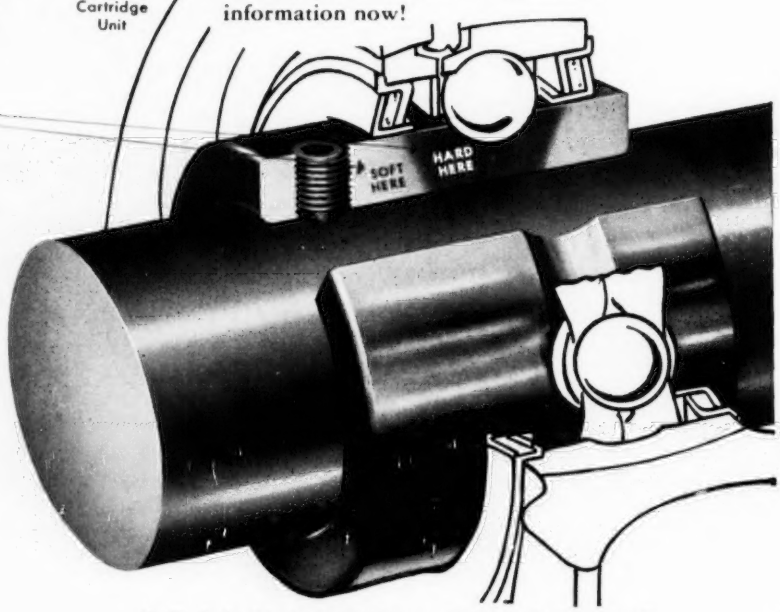
SEALMASTER BALL BEARING UNITS



Cartridge Unit | Flange Unit | Take-Up Unit | Flange-Cartridge Unit

With Zone Hardening, the inner race of the bearing is hardened through the ball path section only. The rest of the race is left in its original, metallurgically soft state. The threads of the hardened set-screws bind firmly in this softer portion of the race and cannot work loose. This insures positive race-to-shaft locking for the life of the bearing.

In the machines you design, build or use, SEALMASTER Zone Hardening means better bearing performance, less maintenance and replacement costs. Write for full information now!



***ZONE HARDENING**

is a completely automatic heat treating process with timing controlled *to the tenth of a second.* In addition to enabling positive race-to-shaft locking, it provides a finer grained, metallurgical structure of uniform hardness in the ball path section. This gives better load carrying ability. Zone Hardening is patented . . . only SEALMASTERS have it.

SEALMASTER BEARINGS

A DIVISION OF STEPHENS-ADAMSON MFG. COMPANY
67 RIDGEWAY AVENUE, AURORA, ILLINOIS

FACTORY REPRESENTATIVES AND DEALERS IN ALL PRINCIPAL CITIES

ONE OF A SERIES

You Get Many Benefits
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Undivided responsibility is important in hydraulics, too. This is a significant benefit you derive from specifying Vickers Hydraulics. Since 1921, Vickers has accumulated a great store of specialized knowledge in hydraulics . . . and the line of equipment is so complete that Vickers is in position to take UNDIVIDED RESPONSIBILITY. There is no risk of incompatibility of equipment and Vickers Application Engineers know how to combine components for optimum operation.

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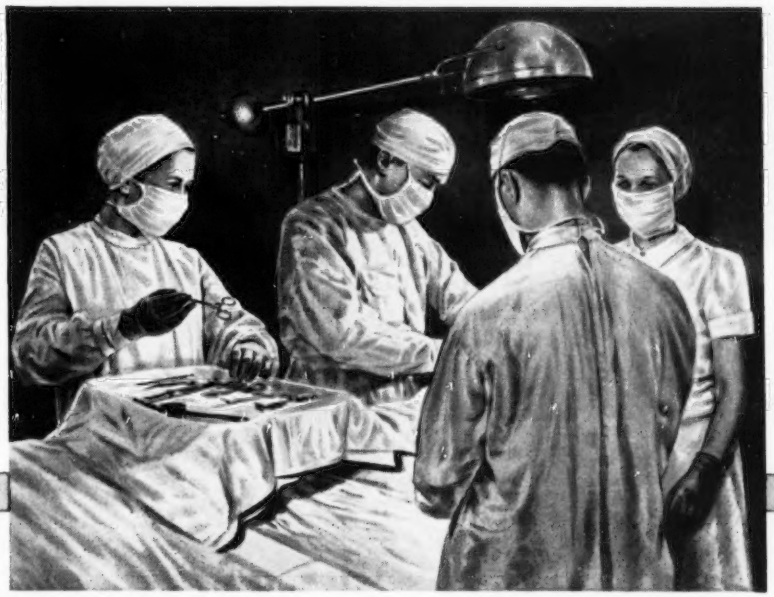

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ENGINEERS AND BUILDERS OF OIL HYDRAULIC EQUIPMENT SINCE 1921

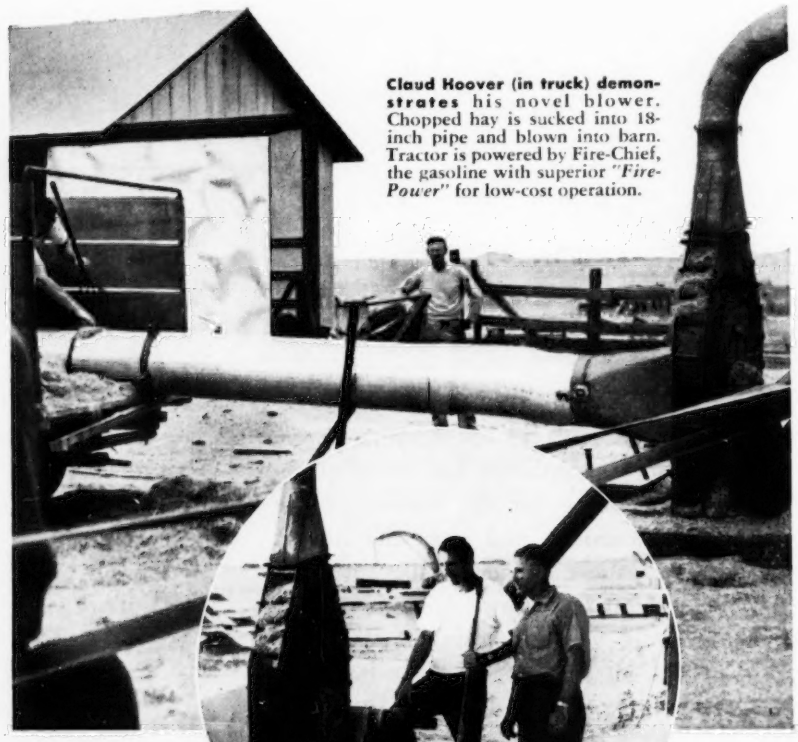
Takes the Labor out of Haying

• Hay is an important crop on the 2,500-acre Hoover ranch near Medford, Oregon, for the Hoovers have 500 head of registered Herefords and some 300 calves to feed.

The Hoovers seed by airplane, covering 100 acres in 20 minutes, and grow grass over seven feet tall.

Claud Hoover has eliminated most of the labor of getting chopped hay into the barn with blower he built. With it, one man can put six or seven tons of hay in the barn in an hour.

The Hoovers have been using Texaco Products for many years. "You can't beat them," they say.



Claud Hoover (in truck) demonstrates his novel blower. Chopped hay is sucked into 18-inch pipe and blown into barn. Tractor is powered by Fire-Chief, the gasoline with superior *"Fire-Power"* for low-cost operation.

Claud Hoover (left) explains operation of blower to Texaco Man K. B. Teeter. Bearings are lubricated with Marfak because this famous lubricant not only seals out grit and dirt but won't jar off, melt down, drip out or dry out and cake up. It stays on the job longer.

Another Claud Hoover idea — This silo, made with bulldozer and boards at a cost of less than $1,000, holds 1,500 tons of silage. Claud is shown talking with C. H. Davis, truck driver for Texaco Man K. B. Teeter of Medford, Oregon.

Three generations of the Scott family of McKinney, Texas. (Left to right): J. C. Scott, Master Larry and Wayne hear from Texaco Man Jess Dale why Havoline is the ideal motor oil. It's the Heavy Duty oil that practically eliminates wear. It stands up better than others in gasoline and Diesel engines and motors using LP-Gas as fuel. It keeps engines clean and better lubricated.

Friendly service with on-time deliveries are what farmers and ranchers appreciate and get from Texaco Men. Mr. William Palm (right), who operates a 950-acre ranch near Sealy, Texas, gets that kind of service from Edmond Luhn, driver for Texaco Man R. R. Hillebrand.

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THE TEXAS COMPANY

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DIVISION OFFICES: Atlanta 1, Ga.; Boston 17, Mass.; Buffalo 3, N. Y.; Butte, Mont.; Chicago 4, Ill.; Dallas 2, Tex.; Denver 5, Colo.; Houston 1, Tex.; Indianapolis 1, Ind.; Los Angeles 15, Calif.; Minneapolis 3, Minn.; New Orleans 6, La.; New York 17, N. Y.; Norfolk 1, Va.; Seattle 11, Wash.

Texaco Petroleum Products are Manufactured and Distributed in Canada by McColl-Frontenac Oil Company Limited.

Densely overgrown land, previously thought too tough to tackle, is now being cleared quickly and profitably with the Allis-Chalmers HD-20.

Land Clearing at its Level Best

with the HD-20 Hydraulic Torque Converter Tractor

Stubborn trees give up *fast* under the smooth, pyramiding power of an Allis-Chalmers HD-20. A steady building up of pressure in the torque converter brings an increasingly powerful pushing force against stumps, big boulders, trees and underbrush. Power, multiplied up to four and one-half times, is applied against a load until the load gives way! There's no need for ramming or butting . . . no engine stalling regardless of load.

Because there are no sudden shock loads — so common in work of this type — tractor and equipment life is longer, upkeep costs are lower.

Ease of operation adds still further to land clearing efficiency. Maneuvers easier than a lightweight in any terrain. Hydraulic steering clutches respond to the touch of a finger.

Take this exclusive torque converter drive, add the kind of traction that only this 20-ton crawler can give and you have land clearing at its level best.

Write for free catalogs, or get the full story from your Allis-Chalmers dealer.

Allis-Chalmers HD-20
Hydraulic torque converter drive
175 net engine hp., 41,000 lb.

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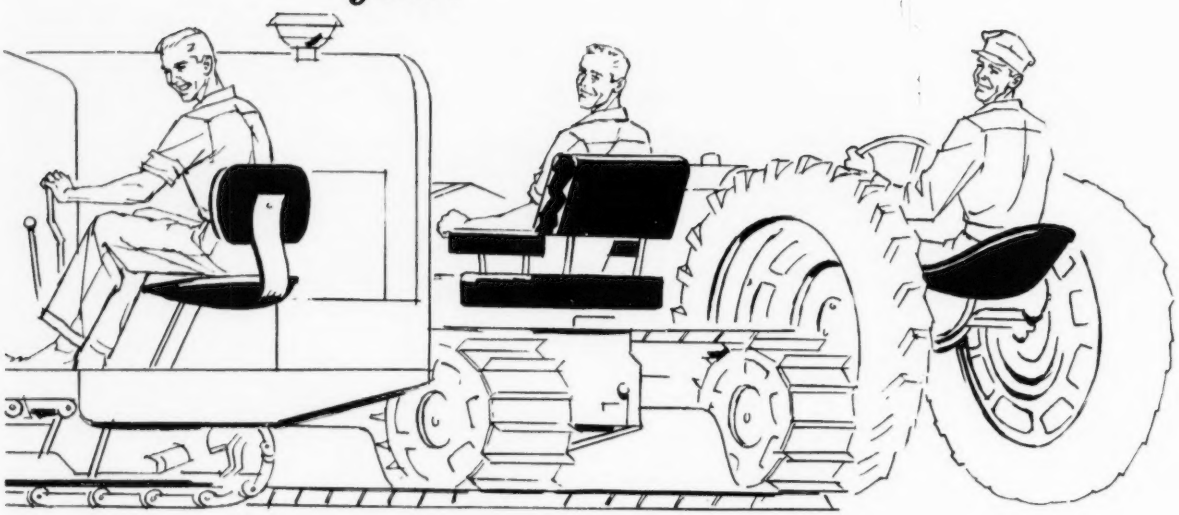

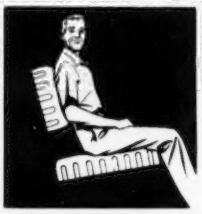

The jolts and jars, shocks and vibrations farmers absorb in their daily work are a needless cause of body fatigue. Let U. S. Koylon Foam on tractor, combine, harvester seats help cushion against them. It gives full uniform resilience, actually puts a shock-absorbing barrier of pure latex filled with millions of tiny air bubbles between the individual and his vehicle. The buoyant, bracing comfort of U. S. Koylon Foam Cushioning is day-long protection against tiring farm work . . . write to the address below for complete information today!

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At the end of a day
. . . the comfort and relaxation of smart furniture cushioned with U. S. Koylon Foam is a welcome feeling . . . a long-term investment for the home.

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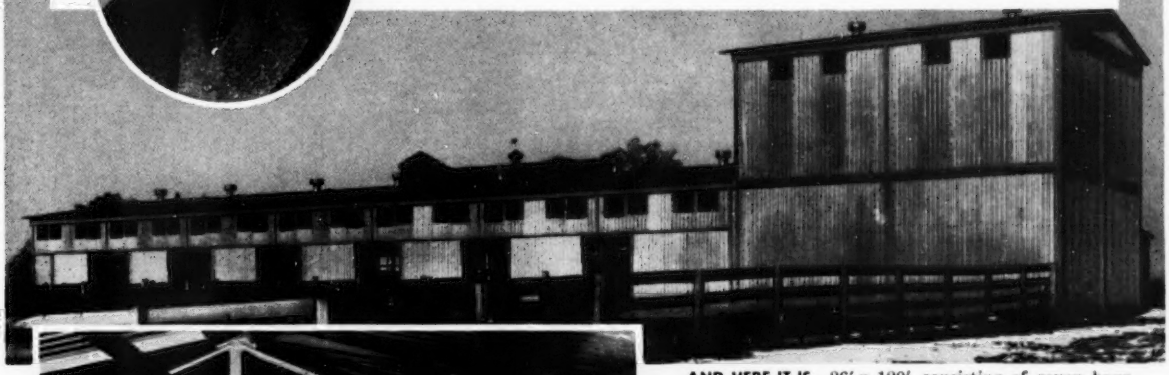
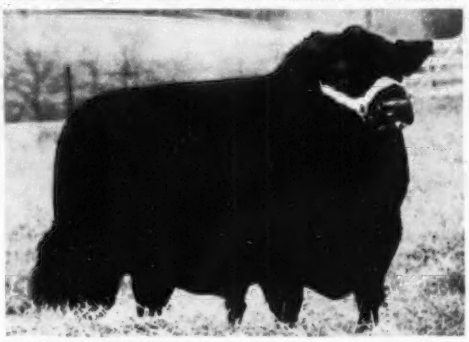
says Harold O. Reif, Renfrew, Pennsylvania



AND HERE IT IS—26′ x 120′, consisting of seven bays and a 20-foot-high feed storage area. There is plenty of room here for the prize cattle and for storage, and the building is safe—as fire resistant as possible.

THEIR OPEN INTERIORS and many windows provide these steel buildings with plenty of sunlight—make them easy to ventilate, easy to clean.



BURGESS BANDOLIER of Anoka 8th, #1022319, Canadian Grand Champion Aberdeen-Angus Bull, Chief Herd Sire at Bonniecroft Farms.

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"It would have to be reasonable in cost, yet sturdy and durable—attractive in appearance and with ample daylight—easy to clean and to maintain—roomy enough to accommodate various classifications of cattle in separate pens—large enough for hay and straw storage—well ventilated, yet not drafty—and above all, as fire resistant as possible.

"I am very proud of my steel building because it not only meets the above requirements, but I find that my cattle are better cared for with less effort and are more easily maintained in a thrifty condition."

Take it from the man who knows—*you get more for your money when you buy a prefabricated steel building.*

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"We ran this engine 39 days straight, day and night, last summer during the dry spell," reports B. V. Conrardy of Marienthal, Kansas, who uses a 3-cylinder GM Diesel to drive an irrigation pump. Mr. Conrardy says the engine has been working six months a year since 1947 and hasn't cost him a dollar for repairs. After seeing the simplicity and economy of the engine, he installed a GM Diesel in a 5-plow tractor in 1948 and also repowered a 3-plow tractor in 1950.

"It used to take 38 minutes to grind 100 bushels of wheat. Now it takes only 27 because this engine doesn't slow up under sudden load increases," says John Jaster, who replaced the gasoline engine on his portable feed mill with a GM Diesel. He can grind 30% more feed per day, and that means a lot more jobs. The 65 H.P. Diesel burns about 3½ gallons of fuel per hour. "Compared with my gas engine, this Diesel is doing 30% more work and costing 65% *less* to run."

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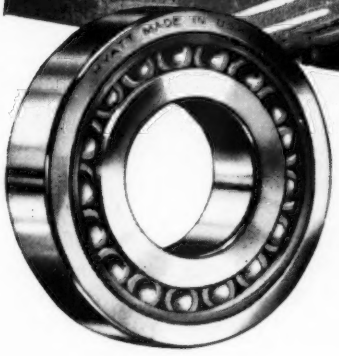

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An exclusive Blood Brothers feature, these Integral Safety Shields have won wide approval in the field for years. Today they are used on mowing machines, corn pickers, forage harvesters, hammer mills and other implements. You can specify them on assemblies from the K-1-C Series on through 35N Series sizes . . . on non-slip front or two-joint slip assemblies.

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For farm implements, more Blood Brothers Universal Joints are used than all other makes combined.

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AGRICULTURAL ENGINEERING

VOL. 34 AUGUST, 1953 No. 8

Design Factors for Hill-Drop Planters

J. W. Autry and E. W. Schroeder
MEMBER ASAE MEMBER ASAE

COMPLETE mechanization of a crop presupposes that it must be planted to a stand. Wide variation in size of seeds, low germination, and poor ability of cotton seedlings to emerge are factors which make hill planting more successful than drilling when "planting to a stand." These factors and simplicity of the equipment favor the use of a hill-drop plate and planter without boot valves. However, this type planter usually results in inaccurately metered and badly dispersed hills, particularly where planting is done at high speeds. This study covers investigation directed toward the establishment of certain principles of design which minimize these disadvantages.

To narrow the scope of the work, one type planter, one variety of delinted seed, and one seeding rate were used. A conventional planter with a horizontal plate, yielding cutoff, roller knockout, and smooth seed tube were mounted on a stand and driven through a series of sprockets, chains, belts, and pulleys by an electric motor (Fig. 1). An endless-chain conveyor was constructed under the planter to carry greased boards (Fig. 2) at appropriate planting speeds. The grease used on these boards was of such consistency as to receive and retain the seed as they fell from the seed tube.

The seed used in this project were of high quality, available to all farmers, and described by the distributor as "acid delinted, floatation graded." The method by which these seeds were processed left them clean and smooth; however, due to the nature of cotton seed they were still somewhat variable in size and shape; consequently, for certain of these tests the seeds were sized on screens selected to eliminate the very large and very small ones.

For the purpose of this investigation, a rate of 3 to 5 seeds per hill was selected. The percentage of hills within that range was used as an expression of accuracy. A series of tests was made to determine the effect of cell shape, plate peripheral speed, uniformity of seed size, and the number of cells per plate on accuracy of metering. The greased board was passed beneath the seed tube while each of the four plates (Fig. 3) was operated at peripheral speeds ranging from 25 to 95 fpm. The rows were duplicated with both regular and sized seed. A record was kept of the number of seed deposited in each hill. Table 1 shows the effect of cell shape and uniformity of seed size on accuracy.

Tests were also made with the same plates containing different numbers of cells. The results of these tests are shown in Table 2.

The metering characteristics of all plates were similarly affected by plate speed; therefore, a composite curve is shown on the effect of plate speed on accuracy and mean cell fill (Fig. 4).

All plates tested for accuracy of metering gave satisfactory results by the standards selected; therefore, the dispersion characteristics of each were investigated. Careful study disclosed that dispersion occurred as *(a)* the seed left the cell, *(b)* the seed fell through the throat and the seed tubes, and *(c)* the seed struck the furrow.

Evaluating Dispersion. The number of seeds in each hill and their dispersion along the greased board were recorded in this test. Some means of evaluating the results to more accurately present the degree of scattering than could be expressed by a mean was thought to be necessary. A satisfactory dispersion for a hill of five seeds would likely be excessive for a hill of three seeds; consequently, a system of scoring each hill was devised. This system relates the number of seed in the hill to the dispersion, and assesses progressively greater penalty to badly scattered hills. The over-all score for each condition was obtained by averaging the scores of the individual hills. The value obtained was called Y in this report. As the value of Y for any condition approaches 1, the more compact are the hills. A value of Y that is less than the mean, M, indicates compact hills. A value of Y that is greater than the mean indicates a significant number of scattered hills. The dispersion characteristics of any set of conditions may be evaluated by observing Y and comparing it with the mean.

Preliminary investigations showed

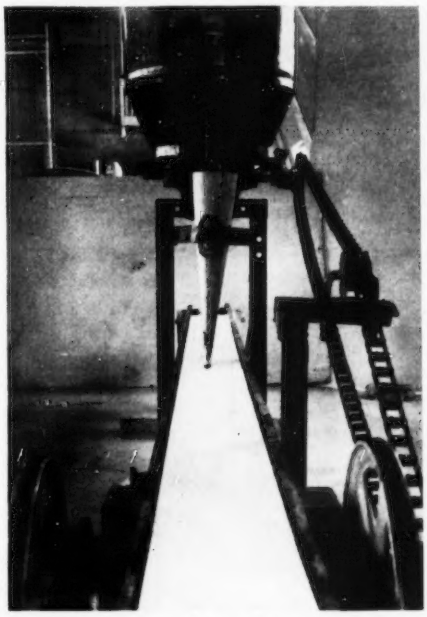

Fig. 1 Equipment used for studying planting equipment. Broken line shows path of seed through trajectory-type seed tube

This paper was presented at a meeting of the Southwest Section of the American Society of Agricultural Engineers at Texarkana, Texas, March, 1951. *(Editor's Note:* More detailed data may be obtained from master's thesis "Simplified Method of Planting Cotton," J. W. Autry, 1950, Oklahoma A. & M. College.)

The authors—J. W. AUTRY and E. W. SCHROEDER—are, respectively, professor and director of division of agriculture, Tarleton State College, Stephenville, Tex. (former graduate fellow, agricultural engineering department, Oklahoma A. & M. College) and professor and head, agricultural engineering department, Oklahoma A. & M. College, Stillwater.

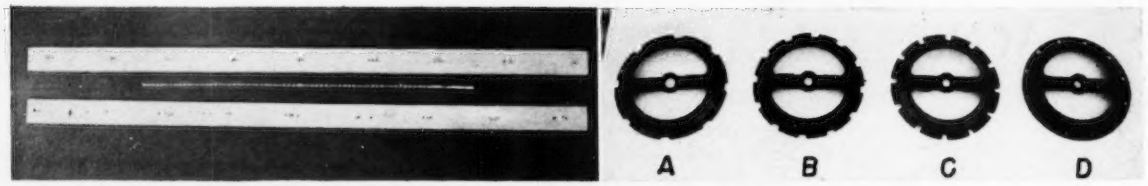

Fig. 2 *(Left)* Seed adhering to grease board in this picture shows amount of dispersion. Dispersion characteristics of plate C using star knockout (top board) and of plate B with roller knockout bottoms • Fig. 3 *(Right)* Left to right, full-hill seed plates A, B, C, and D. Highest accuracy and minimum dispersion was obtained with plate C

that, if all the seeds comprising one hill should issue from the cell simultaneously, and if they should fall without interference, they would reach the ground in a compact group. Such a condition rarely occurs in actual practice. Dispersion from the cell can be shown as a function of longitudinal cell dimension (or cell shape), plate speed, location of the knockout relative to the false ring opening, and the ground speed of the planter. The time lag between seed as they fall from the cell is the same regardless of the distance of fall; therefore, cell dispersion is not affected by the height of the box, unless there is interference in the seed tube.

TABLE 1. EFFECT OF CELL SHAPE AND UNIFORMITY OF SEED SIZE ON ACCURACY

	Plate A			Plate B	
Seed per hill	Seed per hill as a percent of total hills Regular	Sized	Seed per hill	Seed per hill as a percent of total hills Regular	Sized
2	5.0	5.3	2	0.8	2.2
3	34.7	52.0	3	25.6	42.6
4	41.0	40.3	4	54.8	48.0
5	17.6	2.3	5	15.6	6.8
6	1.7	0	6	3.2	0.4
Accuracy	93.3	94.7	Accuracy	96.0	97.4
	Plate C			Plate D	
Seed per hill	Seed per hill as a percent of total hills Regular	Sized	Seed	Seed per hill as a percent of total hills Regular	Sized
2	0.6	1.8	2	3.3	6.2
3	29.1	38.3	3	41.8	58.2
4	52.5	52.0	4	47.8	34.9
5	16.4	7.9	5	6.4	0.7
6	1.4	0	6	0.7	0
Accuracy	98.0	98.2	Accuracy	96.0	93.8

TABLE 2. EFFECT OF NUMBER OF CELLS ON CELL FILL (REGULAR SEED, 25 FPM)

	4 cells		8 cells		12 cells		16 cells	
Plate	Mean	Accuracy, percent	Mean	Accuracy, percent	Mean	Accuracy, percent	Mean	Accuracy, percent
A	3.93	96.7	4.02	95.6	4.07	97.5	3.91	95.7
B	4.14	96.0	4.23	96.1	4.13	96.8	4.06	95.5
C	3.91	97.7	3.79	97.5	3.85	98.7	3.92	93.3
D	3.66	98.7	3.61	98.5	3.74	97.5	3.67	94.5

A series of tests using a commercial type smooth seed tube (Fig. 5) to determine some of the effects of the factors affecting cell dispersion soon revealed that the tube itself was causing considerable scattering of seed. Greased board runs made under a completely free-fall condition showed a surprising compactness of hills. A tube which would permit an undisturbed fall would have to conform in some measure to the path of the falling seed, hence some knowledge of the characteristics of that path was necessary.

As the seeds are ejected from the cell, they have motion relative to the ground in three planes. In the Y plane, this motion is caused by the force of gravity; in the X plane, by the peripheral speed of the plate; and in the Z plane, by the ground speed of the planter. With respect to the tube, motion is only in the X and Y planes because the tube moves in the Z plane at the same speed as the seed. An expression for the path taken by the seed with respect to the tube in a free fall may be developed as follows:

Where V_o = initial vertical velocity of the seed, fps

V_p = peripheral speed of the plate, fps

V = velocity of the falling seed after time, t, fps

Then $X = V_p t$ . . . . . [1]

$Y = V_o t + \frac{1}{2} g t^2$ . . . . . [2]

Most of the seed probably fall without being ejected by the knockout; therefore, V_o was assumed to be 0;

Then $Y = \frac{1}{2} g t^2$

Eliminating t from equation [2]

$t = X/V_p$ from equation [1]

$Y = (\frac{1}{2})(32.2)(X/V_p)^2 = 16.1\ X^2/V_p 2$

or $X^2 = V_p^2 Y/16.1$ . . . . . [3]

Equation [3] is of the general form of a parabola, $X^2 = 2PY$, where $2P = V_p^2/16.1$.

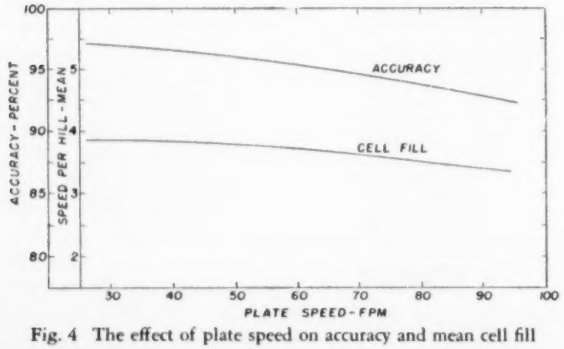

Fig. 4 The effect of plate speed on accuracy and mean cell fill

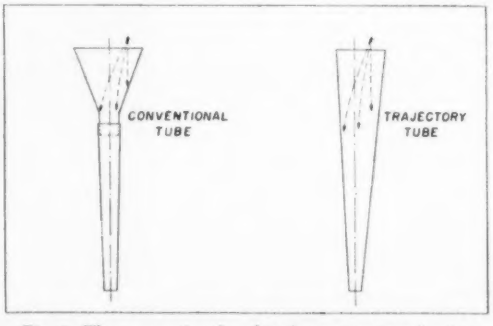

Fig. 5 The conventional and trajectory-type seed tubes

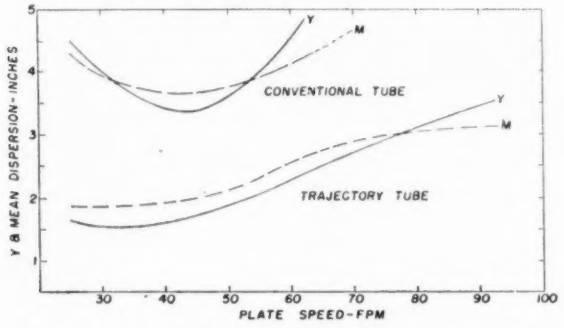

Fig. 6 A comparison of dispersion effects of the conventional and trajectory-type seed tube, plate C

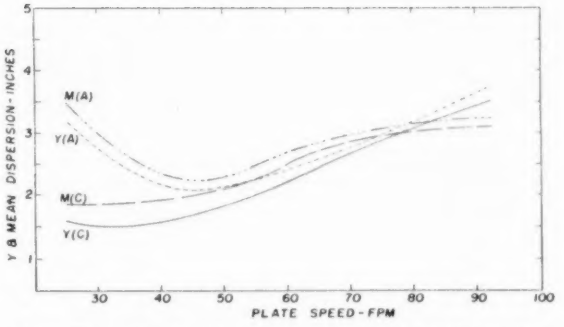

Fig. 7 Dispersion characteristics of plates A and C with trajectory tube, 2.8 mph, 18-in fall

The seed tube therefore must be designed to convey the seeds through a path approximately a parabola if the seeds are to fall without interference from the tube itself. The path of the seeds is varied by changes in plate speed *(V_p)*; consequently, the tube must also conform in some degree to variations of the parabola resulting from increased speed or from an initial velocity imparted to the seed by the knockout.

Eliminating or minimizing seed-tube dispersion was thus reduced to a matter of designing a trajectory-type tube. The tube shown in Fig. 5 was constructed. The shape and slope were designed to conform as nearly as possible to the seed path and maintain as low an angle of impact as possible. The top of the tube was made large enough to conform to the seed path as affected by plate speeds and knockout effects.

A series of tests with the newly designed tube showed marked improvement in hill compactness (Fig. 6). Not only were dispersion values much lower with the trajectory tube, but they were also low over a greater range of plate speeds.

A comparison of all the dispersion curves reveals certain significant features. The optimum plate speed was greater for a long cell than for a short cell. There was a tendency for dispersion to increase at the lowest speed, but this effect was more pronounced with longer cells. This trend is logical because the cell is opened more gradually, permitting the seed to fall in succession. Dispersion characteristics of plates A and C are shown in Fig. 7. Dispersion and uniformity characteristics became poorer at higher speeds. The tendency for all curves to flatten at high speeds results from the fact that the dispersion is not an infinite quantity but is controlled by the hill spacing. The effect of the number of cells per plate on dispersion was not significant. An evaluation of the data shows that highest accuracy and minimum dispersion could be obtained under the following conditions:

(a) Use of a trajectory type tube

(b) Use of plate C with a star knockout

(c) Use of a ratio of ground speed to plate speed of approximately 8 to 1. Based on an optimum plate speed of 37 fpm, this ratio permits the plate to operate in a speed range conducive to high cell-fill accuracy and minimum dispersion over the entire range of normal planting speeds.

This set of conditions was used for all subsequent tests.

Tests to determine the effect of ground speed and height of fall on dispersion were made with the hopper placed at 6, 12, 18, 24, and 30 in above the conveyer and at planting speeds of 2, 2.8, 3.5, and 4.5 mph for each height. The seed falling on the greased board eliminated any scattering that would be due to the seed striking the soil. As shown by previous analysis, the height of fall has little or no effect on cell and seed-tube dispersion of seed; however, speed affected dispersion in every instance. Dispersion was somewhat greater at the highest speed for all heights of the hopper. Dispersion was lowest in the vicinity of 3.0 mph. The results of these tests are shown in Fig. 8.

The scattering of seed as they strike the soil is difficult to evaluate because of wide variations in soil conditions and in the design of opening and *(Continued on page 531)*

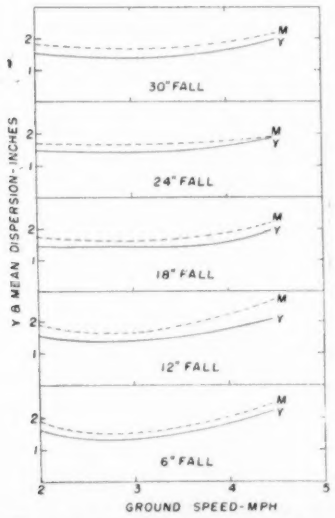

Fig. 8 The effect of ground speed on seed dispersion at various heights of fall

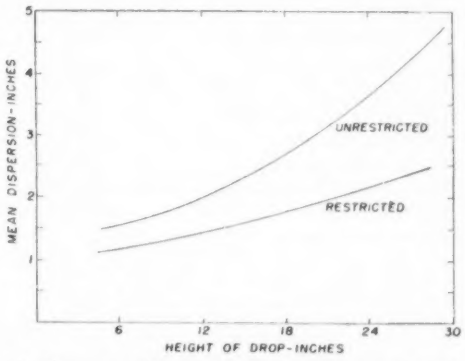

Fig. 9 The effect of height of fall on seed scatter in restricted and unrestricted furrow

Traffic Soles

George R. Free

IT IS recognized that different systems and methods of farming can produce desirable or undesirable physical effects on the soil, but traffic has generally not been considered a separate and distinct variable in this. Soil compaction resulting from traffic, however, may at times be an important factor in soil and water conservation and also in crop production. The amount and kind of traffic associated with farming can vary between wide limits.

In the construction of roads and earth dams, engineers have long been concerned with soil compaction. They should be well qualified to work with compaction problems on agricultural soils even though the objectives are not the same. They should be particularly interested where mechanical forces are involved.

Bacon (1)* in 1929 called attention to the possibility that undesirable compaction might result from tractor wheel traffic. It has been shown that traffic may be a factor of considerable importance in orchards (7). A differential compaction pattern (wheel and non-wheel middles) has been reported for potato plots on Long Island (6, 9). These last investigations were chiefly concerned with compaction produced each year as related to different long-time manure treatments.

Farmers on Long Island have been concerned for some time about soil compaction in a layer just below plow depth. The purpose of this paper is to present and discuss the results of a recent study of this problem.

MATERIALS AND PROCEDURES

Certain plots on an area adjacent to and leased by the Cornell vegetable research farm at Riverhead, Long Island, and certain areas on the game farm of the New York state conservation department at Middle Island were used for this study. Soils at both locations have been mapped by A. J. Baur, state soil scientist for the Soil Conservation Service in New York. The presence of a compact layer below plow depth in the Riverhead area was noted by him when that survey was made in 1948.

Soils at Riverhead were mapped as Sassafras and Woodstown loams, land capability classes 1 and 2. Both are underlain at a depth of 24 to 30 in with rapidly permeable coarse sand with some gravel. The soil at the game farm was mapped as Plymouth which is quite similar to those at Riverhead. Soil textures of the horizons used for this study were all close to the line in the textural diagram separating the loam and sandy loam classes. Therefore, textural variation should not be an important factor in the investigation.

An impact-type penetrometer was used at both locations to measure soil penetrability to a depth of 16 in. The depths reached by the probe under successive blows provided by dropping a 5-lb hammer from a height of 10 in were recorded. The field data were then plotted, and the results expressed as the number of blows required to penetrate each 2-in depth. The probe was ½-in diameter with a larger conical tip on the lower end.

Cores of undisturbed soil, 3 in in diameter and 3 in long, were taken and used for laboratory determinations of volume weight or bulk density, percolation rate, and the volume of pores drained at 60 cm water tension according to the method of Uhland. Samples from these same cores were used for determinations of soil organic matter by the Walkley-Black method, for mechanical analysis using sieves and the Bouyoucos hydrometer method, and also for measurements of the amount of roots.

No attempt was made in securing the last data to differentiate between roots and other undecomposed organic material present. Fragments of soil from the cores were first soaked in water and then washed through a nest of sieves, U. S. sieve numbers 10, 18 and 35. All material remaining on the screens was then transferred to a can of water and the separation of the heavy mineral and the light organic materials accomplished by repeated decanting. The decanted material was then passed through a No. 70 sieve. All roots may not have been recovered and may not have been entirely free from traces of mineral soil. The fact that several samples when burned gave reasonably constant percentages of ash is considered as evidence that the procedure followed was giving comparable and consistant results.

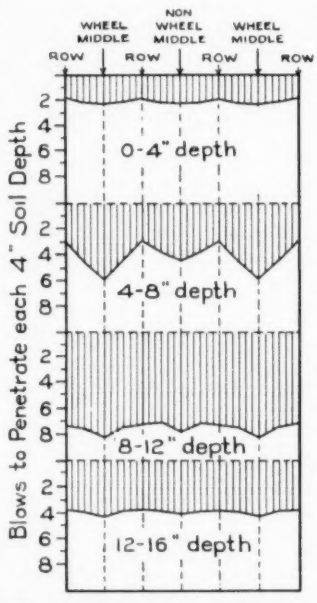

Fig. 1 Soil penetrability across rows of 4-in depths

RESULTS

The first data relating movement of water in the soil at Riverhead to traffic were obtained in the fall of 1951. The two guard or border rows of each potato plot in one experiment had already been harvested. A measured quantity of water was poured in the furrows of the remaining 4 rows of each plot. The distance traveled before it soaked into the soil was used as an index of infiltration capacity.

This paper was presented at a meeting of the North Atlantic Section of the American Society of Agricultural Engineers at Orono, Me., August, 1952. It is a contribution from the Division of Research, Soil Conservation Service, U. S. Department of Agriculture, in cooperation with the Cornell University Agricultural Experiment Station.

The author — GEORGE R. FREE — is a project supervisor of the Soil Conservation Service, USDA.

AUTHOR'S NOTE: The author gratefully acknowledges the assistance of others in this study, particularly that given in the field by W. C. Jacob and P. J. Zwerman of the Cornell experiment station, and laboratory and statistical assistance by E. A. Carleton and J. L. McGuinness of the Soil Conservation Service.

*Numbers in parentheses refer to the appended references.

This is similar to the procedure used by Parker and Jenney (7). The rows had been ridged to a height of about 11 in, and all had a uniform slope of 1 per cent in one direction.

The infiltration characteristics of the soil under some 14 different treatments when measured in this manner were found to be not affected by treatment. The distance traveled by the water in any given row was essentially the same across 4 tiers of plots having different treatments. The ratio of minimum to maximum distance traveled by water in the different rows, however, was about 1 to 4. The minimum distances indicating a high infiltration capacity were found in non-wheel furrows or middles, and the maximum distances indicating a low infiltration capacity were found in wheel middles.

With this degree of ridging, some of the wheel traffic was falling directly on subsoil. It was obvious why organic amendments incorporated since 1949 to plow depth on some plots were not affecting infiltration characteristics measured in this manner. It also seemed logical to believe that the compaction pattern should be rather permanent.

Early in April of 1952 an additional study was made on some of the same plots to determine if a residual traffic pattern could be found. Supposedly rows had been in the same location for 3 years with the ridges partly leveled during digging operations and completely leveled before planting the rye cover crop each fall.

Each year, from plowing in the spring to and including the drilling of cover crop in the fall, these plots had been subjected to tractor traffic amounting to nearly 25 miles per acre. Additional traffic from trailed or drawn equipment has not been included in this estimate. Approximately 60 per cent of the tractor traffic occurred after planting and prior to the start of harvesting operations. This and the planting and digging operations fell into a row pattern ranging from 1-row digging to 10-row spraying.

Another way of expressing the intensity of tractor traffic is to assume that each wheel affected an area one foot wide. The 25 miles per acre is then equivalent to covering every part of an acre 6 times. With the shifts in row location that will naturally occur from year to year in field operations this may be the best way of visualizing cumulative effects over a period of years.

Soil penetrability data to a 16-in depth and at a 6-in horizontal spacing were obtained for 6 plots which included 2 replicates of each of 3 treatments. One of these was the check treatment with no organic amendment. The sampling pattern was systematic and completely covered the 17 ft width of each plot on a line at right angles to direction of row. This meant 204 locations or a total of 1632 values for soil penetrability when the data were finally analyzed on the basis of 2-in-depth increments.

For a statistical analysis of these data by analysis of variance, locations were classified into 5 groups depending upon their closeness to the theoretical position of rows, wheel middles, and non-wheel middles. The data for any location more than 4 in from the theoretical position of any of these were put in 2 separate groups as intermediate positions between row and middles for wheel and non-wheel rows. Theoretical positions were determined by allowing exactly 34 in, measured from the edge of the block, for each row.

It developed later that 6 in would have been a more realistic tolerance for this classification. Nevertheless, highly significant differences between penetrability for the different classifications were found. The mean pattern is shown in Fig. 1. For simplicity, data in this figure are given for 4-in-depth classes. The interaction of classification and depth was significant as might be expected. Even with the rigid tolerance for classification which was used, the traffic pattern is clearly evident at an appreciable depth. It is most pronounced at the 4 to 8-in depth which was of least concern in this study since compaction there is removed, temporarily at least, by plowing.

The 10 to 13-in depth appeared to be a satisfactory one for taking core samples to study any permanent traffic pattern. It was decided to take 2 cores at this depth from each of the 6 plots at locations where the field penetrometer data indicated pronounced "peaks" of penetrability and two where there appeared to be pronounced "troughs". The theoretical position of rows and traffic was not known at the time but was determined later. It is therefore important to note that 22 of the 24 samples thus obtained were within 6 in of the theoretical positions for rows and for wheel middles.

Definite differences in soil structure under the row and middle locations were noted in the field and again in the laboratory when samples were removed from the cylinders. Although the soil at this depth was quite compact at both locations, the structure of that subjected to a fixed pattern of wheel traffic over the 3-year period was consistently more platy than that under the row locations. Roots had not penetrated into the horizontal plates but were concentrated between plates where an occasional vertical opening occurred.

Moisture, density, and other data for the 12 row and 12 wheel-middle samples are given in Table 1. The data in Table 1 show a greater difference between penetrability for row and wheel-middle than is shown in Fig. 1 for the same depth. This is a logical result of procedures followed. The difference shown in Table 1 is considered the better measure of what had happened under extremes of traffic over the 3-year period. There was no great difference in field moisture, organic matter, and percentage of roots, but significant differences between volume weights, percolation rates, and the indices of pore size were found.

It will be noted in Table 1 that both values for volume weight are quite high, and those for large pores, percolation, and roots quite low. Differences within this range may be of rather slight practical importance, except as they

TABLE 1. COMPARISON OF ROW AND MIDDLE SAMPLES FROM 10-13-INCH-DEPTH POTATO PLOTS AT RIVERHEAD, LONG ISLAND

	Moisture*				Penetrability,			
	Field, %	Saturation, %	Volume weight	Large† pores, %	Percolation rate, cc/hr	no of blows	Roots, %	Soil organic matter, %
Row	16.9	23.6	1.62	5.2	23	3.1	0.06	0.73
Middle	15.5	21.6	1.70	3.9	6	6.8	0.05	0.78
Significance‡	NS	*	*	*	*		NS	

* By weight on basis of dry soil.

†Pores drained at tension of 60 cm water—percentage by volume.

‡Differences between means significant at 5 per cent level. NS—not significant.

TABLE 2. COMPARISON OF SAMPLES UNDER DIFFERENT CROPS AND DEPTHS

	Moisture*					Penetrability,		
	Field, %	Saturation, %	Volume weight	Large† pores, %	Percolation rate, cc/hr	no of blows	Roots, %	Soil organic matter, %
Potatoes:								
0-3	15.0	28.9	1.41	8.2	32	1.5	0.31	2.00
10-13	16.2	22.6	1.66	4.6	15	5.0	0.06	0.76
18-21	13.0	23.8	1.55	9.9	121	—	0.07	0.34
Woods:								
0-3	18.6	70.5	1.16	53.0	1042	0.7	—	2.39
10-13	17.7	32.7	1.39	15.8	495	1.7	—	0.83
18-21	16.8	30.0	1.46	15.1	361	—	—	0.64
Range:								
0-3	19.8	35.8	1.38	13.2	218	1.9	0.48	3.02
10-13	18.8	30.2	1.44	11.0	394	2.9	0.38	0.97
18-21	17.8	26.1	1.56	9.1	188	—	0.09	0.44
LSD—5 per cent			0.07	1.9	133		0.09	

* By weight on basis of dry soil.

†Pores drained at tension of 60 cm water—percentage by volume.

contribute to an understanding of the cause of the problem. Water movement was exceedingly slow (116 cc per hour is equivalent to 1 in per hour.) Volume weights are definitely in the range where restriction of root penetration may be expected (11). A good stand of rye was growing on the plots at the time the samples were taken, but few roots were found below plow depth.

A few samples of surface soil at the 0-3-in depth and subsoil at the 18-21-in depth were obtained from the check plots. The data for these samples (Table 2), can be compared with those for the 10-13-in depth. The data in this table for the 10-13-in depth are averages of those in Table 1. It is evident that the compact layer below plow depth restricts water movement through the profile even though permeability of the surface soil is not very great. Part of the restriction in the surface may be due to roots filling the pores. This effect has been noted on other occasions. When plants die and roots decompose, channels are available for infiltration and percolation of water. There were few roots at the lower depths.

Also given in Table 2 are comparable data for the profiles under woods and range at the game farm. The range site has never been intensively cropped so far as is known but has been under a 4-year rotation of corn, oats, and 2 years of sod. The objective in management has been to provide good clean range for the birds. The area sampled was in second year sod and the cover included a small amount of alfalfa.

There was no evidence of platy soil structure in either profile at the game farm. The soil under range cover showed evidence of earthworm activity not found under either woods or potatoes. Liming plus a favorable structure would seem to account for the presence and activity of earthworms. The pH of the surface soil under range was 5.6 compared to 4.6 under woods and under potatoes. (The pH data were supplied by the Cornell agronomy department soil-testing laboratory.)

Soil organic matter at both sites at the game farm was greater than that under intensive cropping to potatoes at Riverhead. The contrast is not as marked, however, as one might expect. Maintenance of a high fertility level for potatoes and other vegetables, the use of rye as a winter cover crop, and the fact that this particular area in potatoes had only a very gentle slope so that erosion losses were not great, have all served to keep soil organic matter from dropping to lower levels.

The proportion of large pores in the surface soil under woods must certainly be considered excessive. Farmers clearing land there do not expect best production the first year. The desirability for some compaction may be the reason for this along with the adjustments necessary in fertility.

DISCUSSION

Compact layers or pans of the kind which were the object of this study have been called "plow soles" by many. The results of this study indicate that "traffic sole" (a designation suggested by Prof. P. J. Zwerman) would be a more accurate term to use under conditions such as these on Long Island.

The compacting action of tractors and other equipment has been clearly demonstrated by others (5, 6, 7, 8, 9, 10, 12, 13). Recognition of compaction resulting from modern agricultural equipment does not mean that one must either turn back to horse-drawn equipment or jump ahead at once to performing all operations with airplanes. There are many alternatives.

One of these consists of breaking the pan by mechanical instruments such as the chisel and subsoil plows. This is being done by some of the growers on Long Island, but Jacob and Russell in a recent study (4) were unable to show any benefits in terms of effects on yields. They concluded that more work is needed on the subject of deep tillage.

Another alternative is to use deep-rooted legumes such as alfalfa and sweet clover to break through the traffic sole. Trials of this character are under way at the present time. However, in addition to the economic problem involved in this or any other proposal involving "resting" in sod, there is a question regarding the length of time such a treatment would be effective under intense traffic during the year or years the cultivated crops were being grown. Certainly the roots and an increase in organic matter should alter the compactibility of the subsoil to some extent at least (1, 2, 9).

The importance of traffic sole from the standpoint of soil and water conservation is obvious. The restriction adds greatly to the difficulty of getting water into and through the soil and may increase water losses by evaporation. Even the less permanent but marked compaction found associated with traffic in the plow layer doubtless has a great effect on infiltration and water movement.

There is reason to believe that reduction in the compactness of the traffic sole on Long Island would be beneficial from the standpoint of crop yields. This, of course, is an important assumption and one that needs study.

In the particular experiment at Riverhead used for this study, yields of potatoes from rows adjacent to spray-wheel traffic were only slightly less than from other rows. It must be kept in mind, however, that this was extra traffic on an already compact soil. It may or may not be significant in this connection that Hardenburg (3) found an

average decrease in potato yields amounting to 22 per cent from sprayer-wheel injury. This study was made in upstate New York and the investigators were apparently thinking more in terms of vine injury than soil compaction.

SUMMARY

The compactness and permeability of intensively cropped soil on Long Island within and below plow depth was shown to be determined by the traffic pattern imposed on the soil during the preceding three years. It was possible to detect and measure the compaction pattern even though all evidence of row location had been removed by leveling and planting of winter cover crop six months before.

A traffic sole or compact layer of soil below plow depth was found where intensive cropping had been followed for several years. There was no such layer under either woods or under range land.

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Hill-Drop Planter Design

(Continued from page 527)

covering devices; therefore, the work on this phase of the project has been limited to determining certain general effects. The extent of scattering at the furrow is related to the kinetic energy ($\frac{1}{2}MV^2$) of each falling seed. The ground scattering should be approximately proportional to the height of the hopper, if the seed are free to disperse as they strike the soil. This effect must be eliminated either by lowering the hopper or by some mechanical method of holding the seed as they reach the furrow. Loose soil would perform this function adequately; but, as most authorities agree that cotton should be planted in firm moist soil, some other solution is necessary.

A series of tests to evaluate ground dispersion were made by dropping three to five seeds in groups from different heights through the trajectory tubes into a firm moist furrow made by a conventional runner-type opener. There were no restrictions and the seed were free to bounce. This test was followed by a similar one with the furrow restricted one inch ahead of the point of impact of the seed, so that bouncing was limited to one direction.

This second test was based on the assumption that the seed tube could be placed in such a position relative to the opener. The data from these tests are plotted in Fig. 6, but are not considered adequate to completely cover this phase of the work. They do, however, indicate the effects of box height and partial restriction of the seed furrow on dispersion.

Fig. 9 also reveals that satisfactory dispersion results can be obtained, provided some method is employed to restrict the dispersion due to bounce of seed as they strike the seed furrow. Forward dispersion has been controlled by locating the seed tube immediately behind the opener. Restriction of scattering in the other direction is more difficult. Satisfactory results have been obtained by placing a small V-type rubber-tired wheel directly behind the seed tube to restrict bouncing in a rearward direction. Not only did this restrict the seed but it also improved the stand obtained.

SUMMARY AND CONCLUSIONS

1 Highest accuracy can be obtained by use of compact-type cells, i.e., short and broad rather than long and narrow cells.

2 Slow plate speeds (below 30 fpm) result in highest accuracy and a higher mean cell fill.

3 Under the present concept of accuracy requirements for cotton, and when planting with a full hill plate, the use of sized seed is not justified, if such seed are higher in price. This conclusion is based on the premise that seed of equal quality to those used in this test are planted. Where higher accuracy is desired, a system of seed screening based on size and shape is required.

4 Accuracy is affected less by changes in the number of cells per plate than by speed changes; consequently, rates should be varied whenever possible by plate changes rather than by plate speed changes.

5 Cell dispersion can be minimized by use of the more compact-type cell with the star-type knockout device.

6 There is little effect of the number of cells per plate on dispersion within the range from 4 to 16. This characteristic permits the use of more cells to obtain a closer spacing without affecting dispersion.

7 A seed tube designed to more nearly convey the seed through their normal path will greatly improve dispersion characteristics for all plates and speeds.

8 Cell and seed-tube dispersion are not affected by the height of fall if a trajectory-type tube is used.

9 Ground scattering is decidedly affected by height of fall, but it may be reduced by partial restriction of the furrow and by use of a hopper height of 18 in or less. Further study on this phase is needed.

10 By selecting the proper ratio of ground speed to plate speed (about 8.2 for the planter used in this work), the effect of ground speed on dispersion can be kept to a minimum.

11 Under the conditions of this test, and using the principles enumerated above for highest accuracy and lowest dispersion, successful precision cotton planting by use of delinted seed with hill-drop plates is indicated.

Performance of Relugged Tractor Tires

I. F. Reed and C. A. Reaves
MEMBER ASAE ASSOC. MEMBER ASAE

SINCE natural rubber must be imported and synthetic rubber could be in short supply in case of a national emergency, the Office of Materials and Facilities of the Production and Marketing Administration, U.S. Department of Agriculture, is continually searching for methods of tire building and rebuilding that conserve these materials. Available information indicates that relugging a 11-38 tractor tire requires only 23 lb of rubber, whereas a recap requires about 56 lb and a new tire requires much more. In view of these facts, the PMA requested the division of agricultural engineering (BPISAE) to determine whether or not relugged tires would stand up and perform satisfactorily.

A study of available information brought out facts that the few users contacted were entirely satisfied with the service rendered and that tests in England showed the relugged tires to be effective. Since the English tests were planned primarily to determine the comparative drawbar pulls of new and relugged tires and information obtained from operators was limited, tests were made at the USDA Tillage Machinery Laboratory to determine whether or not the relugged tires would stand as severe treatment as new or recapped tires.

Method of Testing. Four 11-38 bar-tread tires (one new, one recapped, and two relugged) were obtained and tested on the tire test machine at the Tillage Machinery Laboratory. This machine consists of a tractor with one rear wheel removed and the differential locked so that all power input goes into the remaining wheel. The tractor unit is mounted in a framework with the front end of the tractor supported on anti-friction bearings and the whole so arranged that the car is used to apply loads to the tire to be tested. These loads are measured by special dynamometers as explained by Reed and Berry.* To make these tests as severe as possible, the test car was locked in position, thus producing 100 percent slip on the tires tested.

The following tests were used to determine whether or not one type of tread could be torn off more easily than one of the others. Each succeeding test condition was planned to be more severe in its reaction on the tire tread. The test conditions were as follows:

1 On medium rough concrete, 60 revolutions.

2 On the sharp corner of a concrete wall with center of axle one inch behind corner, 100 revolutions (Fig. 1).

3 On a steel plate on which two ⅜ x ⅜-in steel bars were welded to form an open center V having an included angle of 125 deg, 40 revolutions. The center was left open because the lugs overlapped in center of the tire tread.

4 On a steel plate having a ¾ x ¾ x 2½-in steel bar set at right angles to the direction of tire rotation, 20 revolutions. Only one bar was used, thus concentrating the load on one lug. This bar was set so that its outer end was flush with the outside of the tire tread.

The static load was held constant at 2185 lb throughout all tests. Inflation pressure was 12 psi with the tire set on concrete and under static load for all tests except the last ten revolutions on the V bars. It was raised to 20 psi for these tests. The tire temperature was watched closely during all tests and kept low to prevent any possible lubrication due to

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The authors — I. F. REED and C. A. REAVES — are, respectively, senior agricultural engineer and associate agricultural engineer, division of farm machinery (BPISAE), Tillage Machinery Laboratory, U.S. Department of Agriculture.

*Equipment and Procedures for Farm Tractor Tire Studies, Reed, I. F., and Berry, M. O. AGRICULTURAL ENGINEERING, vol. 30, February, 1949.

Fig. 1 View of a tire under test on the sharp corner of a concrete wall. Note severe wrinkling of tire and twisting of lug. Inflation, 12 psi; static load, 2185 lb

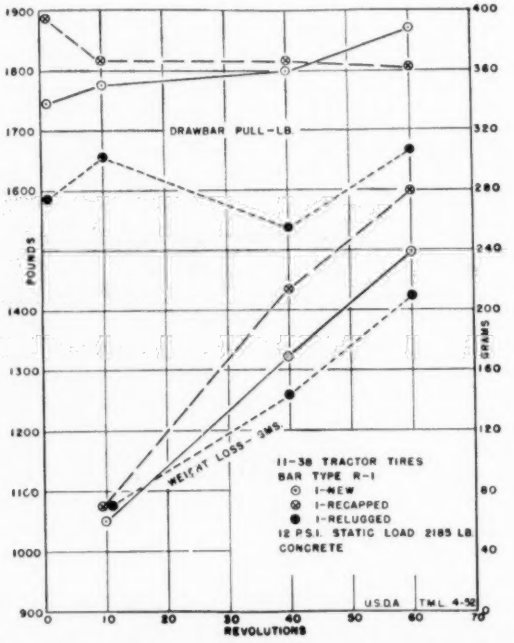

Fig. 2 Relative drawbar pull and weight loss for the three tires used in the USDA tests on medium rough concrete

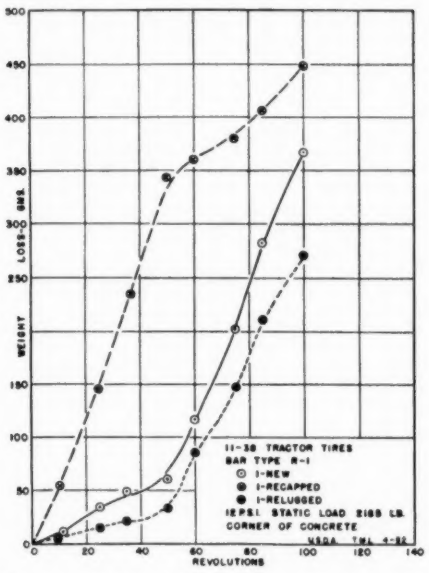

Fig. 3 Relative weight loss for the three tractor tires on a sharp corner of concrete. Loads fluctuated markedly as the lugs passed over the corner. They could not be evaluated effectively

heating of the rubber. The speed was 1.1 mph for tests on concrete and corner of concrete, 0.8 mph for those on the V bars, and 0.6 mph for those on the ¾ x ¾ x 2½-in steel bar.

Test Data. Measurements of drawbar pull, torque or power input, and tire weight loss were taken simultaneously periodically throughout the tests, except that no weight loss data were recorded for tests on the ¾ x ¾ x 2½-in steel bar. It was not deemed necessary to obtain a continuous record of these data since the primary objective of this study was to determine whether or not the lugs on the relugged tires would stand as severe service as those on new and recapped tires.

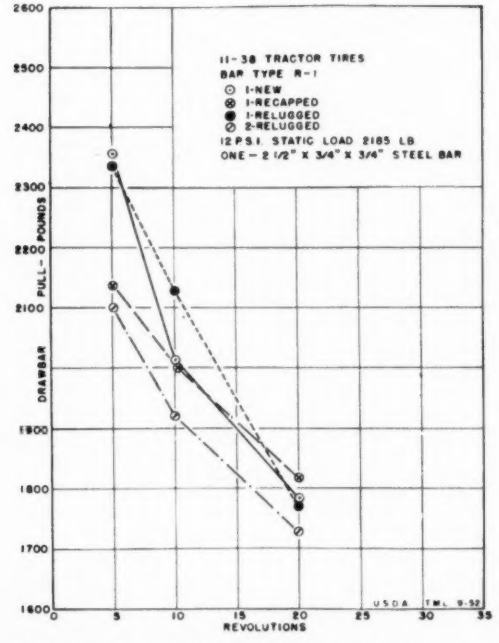

Fig. 5 Drawbar pulls for the three tires on a ¾ x ¾ x 2½-in steel bar set perpendicular to direction of tire rotation

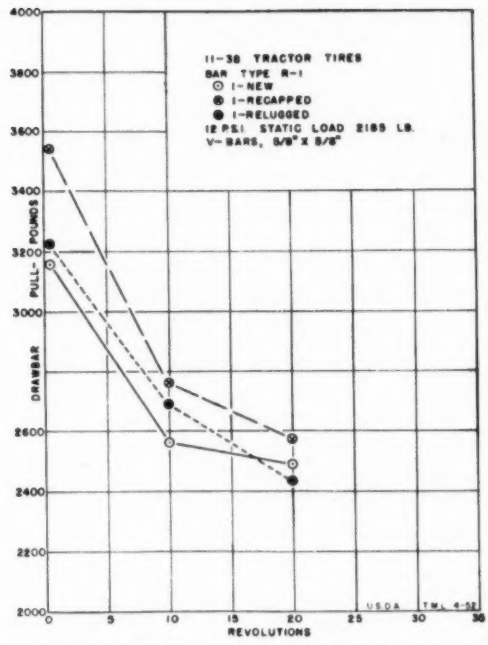

Fig. 4 Drawbar pulls for the three tires on ⅝ x ⅝-in steel V bars with open center and an included angle of 125 deg

Test Results. Data for all tests are shown graphically in Figs. 2, 3, 4, and 5 with drawbar pull and weight loss (where measured) plotted against revolutions of the tire. Figs. 2 and 3 show that the rate of weight loss from the relugged tire was less than that of the new tire and that the rate of wear for the recapped tire was considerably greater than either. It should be noted that the lug height was 15/16 in for the recapped tire and 1¼ in for the new tire and relugged tire. The total loss for the three types of treads for tests prior to those on the ¾ x ¾ x 2½-in bar was 516 grams for the relugged tire, 631 grams for the new tire, and 787 grams for the recapped tire. The low loss for the relugged tire may be partially explained by the fact that these lugs were cold rubber, whereas so-called hot rubber was used for the other tires. The difference in rubber loss between the new and recapped tires may have been partially due to composition of the rubber and partly due to lug height. The shorter lugs flexed less, probably subjecting them to a more severe rubbing action. This is indicated also by the higher drawbar pull for the recapped tire. Relative weight losses for the new and relugged tires were in line with the results reported for the English tests.

Though the tests reported here were planned primarily to determine whether or not the relugged tires would stand up as well as the lugs on new tires or recapped tires, periodic drawbar pull measurements were made (Figs. 2, 4, and 5). These data indicate that the short rigid lugs of the recapped tire gave the highest drawbar pulls for most of the test conditions. A second relugged tire was tested on the ¾ x ¾ x 2½-in bar without the preliminary runs on concrete, etc. The drawbar pull was below that for the other relugged tires, Fig. 5. This was probably due to the fact that the unworn lugs were more *(Continued on page 544)*

Absorption Rates of "Penta" by Various Species of Wood

L. W. Neubauer and R. F. Grah
MEMBER ASAE

FARMERS of the United States are using millions of wooden fence posts and poles of durable as well as non-durable species. Many of these require a chemical treatment of some type in order to improve their service life and economy.

California ranches have many suitable fence-post woods, both softwood and hardwood, most of which require some type of preservative treatment to make them sufficiently durable. The softwoods are particularly numerous and suitable in shape. The heartwood of some of these is naturally durable, notably in redwood and cedar, but when used as whole round posts they also require treatment. Several materials can be used to improve durability, including creosote, pentachlorophenol, chromated zinc chloride, and copper naphthenate. Pentachlorophenol, or "penta," is recognized as a good wood preservative, is easily available, clean and easily handled; thus it is particularly well adapted to use by farmers and other individuals. In connection with an extensive series of durability tests at the University of California at Davis, it was desired to also determine the rates and amounts of absorption of pentachlorophenol in Diesel oil, by woods of several species, treated under different cold-soaking methods adapted for farm use.

PROCEDURE

Posts selected were of types and sizes easily available and often used in several regions of California. They ranged from the common 2 x 2-in split grape stakes, generally redwood, through the small fence posts of about 3-in diameter, up to a maximum diameter of nearly 7 in for a few species. Most were types native to the region, although a few such as eucalyptus and tamarix are exotic species now extensively grown in California. Nearly all were collected from second-growth stands or plantations and contained a large percentage of sapwood.

Length of the posts averaged about 7 ft, as commonly used on farms. This allowed setting them about 30 in deep in the ground and extending 4½ ft above ground level, permitting the annual strength tests at a height of 48 in above grade.

Peeling the bark was done immediately or soon after cutting. One notable exception was tamarix, usually crooked and fluted, with bark adhering tightly, so that peeling was impractical and uneconomical.

Seasoning was thorough, averaging over a year in a climate having long hot and dry summers, with the posts protected from rain during wet seasons. The moisture content at the time of treating was in the neighborhood of 10 per cent.

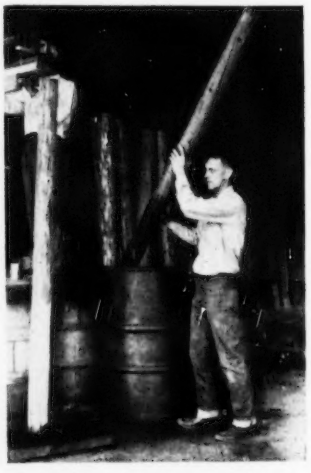

Fig. 1 General arrangement for post treating and weighing

VARIABLES IN PREPARATION

Cold Soaking. A 110-gal drum was used for most of the cold-soaking, as shown in Fig. 1. This was tall enough to treat the posts to the necessary depth. An overflow pipe was used to assist in controlling the depth of liquid. A pulley and rope above the drum were used to raise the heavy posts one at a time, out of the oil, for frequent weighing. An accurate beam balance was also mounted above the tank so each post could be weighed, to the nearest gram, while surplus oil drained off. Absorption was measured by actual increase in weight of each post. Weights of some posts were recorded at one-minute intervals during the first 10 min; subsequently at longer intervals. More than 80 posts of ten species were cold-soaked by this method. A formula and chart were used to easily convert grams increase in weight to absorption in pounds per cubic foot of wood.

Incising. Similar groups of nine species of posts were incised in order to determine the general effect, the resulting increase in absorption, and the improved durability in the ground. Incising was done with an axe or heavy metal plate fitted with a group of chisel or screwdriver-shaped points, ⅜ to ½ in long. These were applied so as to cut across the grain of the wood in a staggered pattern, thus exposing additional end grain and increasing oil absorption.

Entire posts were not incised; only the area surrounding the region most subject to decay, a few inches below the ground line. A length of about 18 in was so treated, from 4 in above ground line to 14 in below.

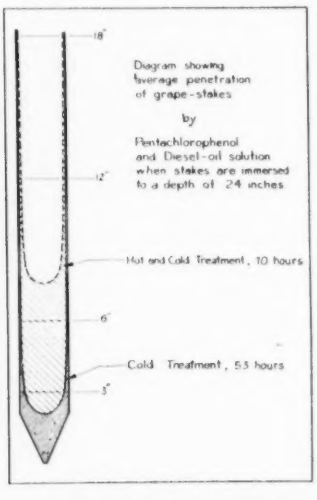

Fig. 2 Penetration of treatments into a redwood grape stake

Depth of incising averaged ¼ to ⅜ in. Absorption would obviously increase with depth of cut, but this also causes weakening of the post. Heavy incising on 2 x 2-in grape stakes was found to decrease their flexural strength as much as 50 percent, so in order to avoid any serious weakening, the depth of cuts was made to vary roughly with the post diameter.

End Coating. A few posts of each of six

This paper was presented at the winter meeting of the American Society of Agricultural Engineers at Chicago, Ill., December, 1952, as a contribution of the Farm Structures Division.

The authors—L. W. NEUBAUER and R. F. GRAH—are, respectively, associate professor of agricultural engineering and extension forester, University of California (Davis).

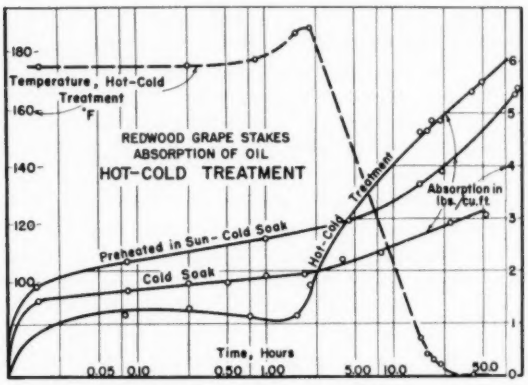

Fig. 3 Hot-cold treatment is most effective

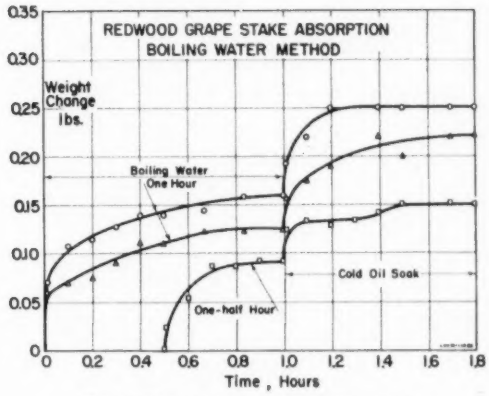

Fig. 4 Hot treatment with boiling water

species were end-coated. This is sometimes done to reduce absorption at the bottom of a post where protection is much less important than near the ground line. Heavy end absorption which normally occurs may be considered wasteful and expensive in some instances. More efficient use of pentachlorophenol would result from a decrease of end absorption and an increase near the ground line. Fig. 2 shows the average depth of absorption for a common redwood grape stake.

Several paints and oils were tested for end coating. Low-cost materials were necessary, as well as simple methods of application. Most paints softened or dissolved when placed in penta and diesel oil. Bituminous coatings gave protection for only a short time. Shellac was found to provide one of the best coatings, and as it was also low in cost, was chosen as the most suitable. A shallow pan of shellac was prepared into which the butt ends of the posts were dipped. After drying, they were given a second dipping. This effectively decreased the amount of penta absorbed. What effect this treatment may have on post life will not be learned for a few years.

Brush Treatments. Posts of five species were given brush treatments. The preservative was applied near the ground level region where treatment is most necessary, in the same area as the incising. A large brush was used and the penta solution applied liberally, the excess being allowed to drain off. A portion of the posts were later given a second brush treatment. A few were incised before brushing.

Spray treatments were also used in one or two operations. Liberal applications were again made, surplus oil being allowed to drain off. The spray gun forced considerable fine oily mists into the air causing breathing difficulty for the operator and increasing the fire hazard, so this method cannot be generally recommended.

Hot and Cold Soaking. Several experiments were conducted using hot and cold-soak methods, as this system is generally believed to be the best of the non-pressure treatments. Fig. 3 illustrates the results of testing a few groups of redwood stakes. An average cold-soak treatment is shown for comparison.

When preheated in the direct rays of the sun, the stakes reached a much higher temperature than usual, and, upon immersion in the cold-oil bath, absorbed the treatment more rapidly. This increase or differential was apparently maintained as long as the treatment continued. Such a process may not often be convenient or feasible, but when possible without expensive preparations it can be expected to improve the penetration.

The standard hot-cold system included heating the oil while the posts were immersed. Instead of an increased absorption of the hot oil, as might have been expected, it was found that the absorption was decreased during the heating operation. This can be explained as a result of the expansion of the air and water vapor in the wood, which tends to force the oil out and prevent penetration. As soon as the oil is allowed to cool off, however, this action is reversed, and the oil is forced into the pores of the wood, resulting in increased penetration and absorption, as shown on the right half of Fig. 3. This method is considered the best of the

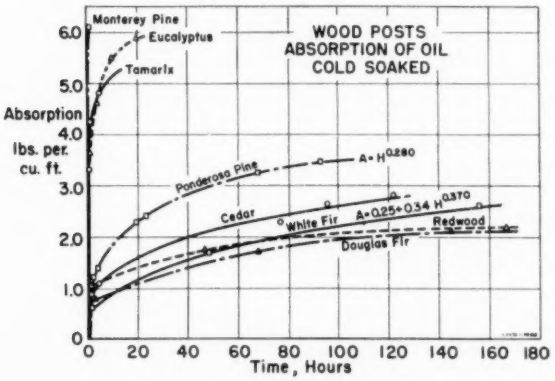

Fig. 5 Average absorptions by cold soaking

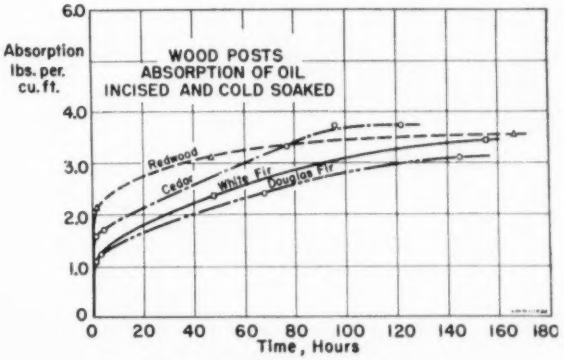

Fig. 6 Absorptions are increased by incising

TABLE 1. FENCE POSTS TREATED WITH PENTACHLOROPHENOL

Species	Treatment	No. of posts	Soaking time, hr	Pounds absorption per cu ft Max.	Min.	Avg.
Monterey pine	Cold soak	5	1	12.4	7.5	9.8
Eucalyptus	"	10	20	10.8	3.2	5.84
Tamarix	"	10	4.25	6.2	3.0	4.57
Ponderosa pine	"	10	93	4.1	2.8	3.43
Incense cedar	"	5	122	3.0	2.6	2.80
White fir	"	10	168	3.7	1.5	2.60
Sugar pine	"	3	169	2.8	2.4	2.53
Redwood	"	9	167	3.1	1.8	2.16
Douglas fir	"	10	145	2.8	1.5	2.10
Douglas fir	"	5	168	2.4	1.6	2.00
Big tree	"	7	169	2.6	1.0	1.94
Monterey pine	Incised	4	1	8.6	5.7	6.72
Tamarix	"	6	4.25	6.3	4.0	5.78
Eucalyptus	"	5	20	8.1	3.4	5.20
Cedar	"	5	122	4.8	3.0	3.72
Redwood	"	5	167	4.5	2.8	3.54
White fir	"	5	168	4.0	2.5	3.45
Douglas fir	"	5	145	3.5	2.4	3.14
Big tree	"	2	169	3.3	2.9	3.10
Sugar pine	"	1	169	—	—	2.80
Tamarix	End coated	5	4.75	4.3	4.0	4.10
Eucalyptus	"	5	20	4.6	2.0	3.08
Ponderosa pine	"	4	168	5.6	4.7	5.10
Douglas fir	"	2	168	2.5	2.0	2.25
White fir	"	5	170	2.3	1.7	2.04
Big tree	"	6	168	2.7	1.4	1.90
Tamarix, bark on	1 brush	1		—	—	1.25
Redwood	1 "	3		0.72	0.47	0.56
Incense cedar, smooth	1 "	5		0.36	0.19	0.28
Douglas fir	1 "	3		0.46	0.39	0.43
Douglas fir	2 "	3		0.78	0.69	0.73
Incense cedar, smooth	2 "	5		0.59	0.29	0.45
Eucalyptus, split	2 "	5		2.00	0.25	0.98
Tamarix, bark on	1 " incised	1		—	—	2.50
Redwood	1 " "	2		1.27	1.17	1.22
Eucalyptus	1 spray	5		1.30	0.55	1.05
Eucalyptus	1 "	5		—	—	1.20
Eucalyptus	2 "	5		—	—	2.10

non-pressure systems, but involves some additional equipment and manipulation, as well as an element of danger because of the heated oil.

One phase of the hot-cold process is the hot or boiling-water method sometimes recommended as being safer and equally effective. Several runs of this type were also made, in order to demonstrate the results, as shown in Fig. 4. While these curves resemble that of the hot-oil treatment of Fig. 3, in that the cold oil is absorbed rapidly, it also appears that considerable hot water is absorbed. In fact, the weight of water absorbed is greater than the weight of oil, making the total oil absorbed relatively low. With these characteristics in mind, it was believed that this process should not be recommended, and no additional experiments of this nature were made.

Selection of Posts. Posts were usually selected in groups of five or ten. Each group included a similar size range, from small to large diameter. Every post was measured for circumference, length, weight, and absorption, and identified by number.

Placement in Field Test Plot. All posts were set in the ground in rows, in numerical order, and in groups of each species having the same treatment. They were set closely enough, 2 ft apart, so that termites and fungus infection might readily be transmitted from post to post. Rows were set farther apart so that small field equipment might be operated to control weeds, and to allow space for strength-test equipment, used annually, to determine serviceable life of each post.

DATA

Posts were treated in groups, set vertically in the drum of penta. Each post was weighed before treatment and then at intervals, so as to clearly define the absorption rates on a time basis. These were found to vary widely with type of wood, incising, end-coating, splitting, size of post, knots, and other factors. It was at first hoped to reach an absorption of 5 or 6 lb per cu ft on all specimens, but this was found impossible in many cases even after a full week of treatment, so a 7-day time limit was arbitrarily selected, unless adequate absorption developed sooner.

Because the amount of data taken was much too voluminous to repeat here, only a simple summary of average values is shown (Table 1). This tabulation includes the pertinent data, consisting of wood species, type of treatment, number of posts in the group, time of soaking in hours, maximum, minimum, and average absorption in pounds per cubic foot. These 38 conditions are also shown graphically in several figures.

Cold Soaking. The largest number of posts, with the exception of non-treated or check groups, were given a common cold-soaking bath or steep. Heat treatments, although

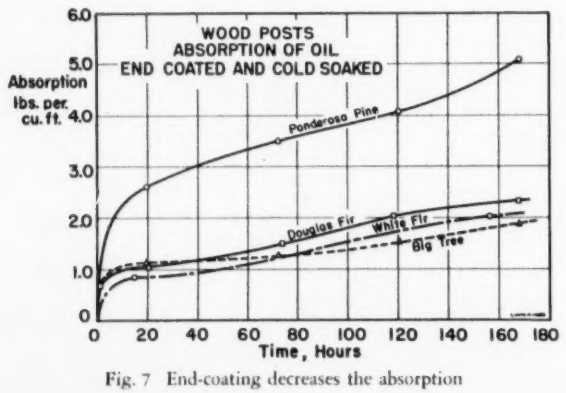

Fig. 7 End-coating decreases the absorption

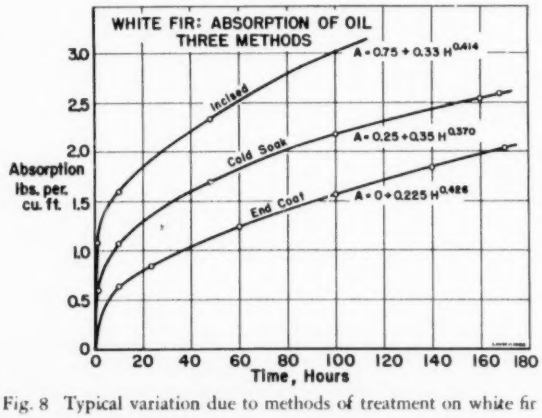

Fig. 8 Typical variation due to methods of treatment on white fir

recognized as superior, were found time-consuming, expensive, and hazardous because of the danger of fire, and were not used in these tests. The general relationship for several species of wood is shown on Fig. 5.

A wide divergence was found in absorption rates among different species of wood. While several softwoods absorbed only 2 or 3 lb of oil per cubic foot in a week's time, the two hardwoods absorbed twice as much in a few hours. The most rapid absorption, however, occurred with another softwood, Monterey pine, which averaged over 6 lb gain in one hour. Thus it may be very important to the farmer to know what time period of treatment should be required for each kind of wood.

Incised. Fig. 6 shows rates for a similar group of soft woods after being incised. This treatment was expected to increase the absorption, and actually did, by an average of about one pound per cubic foot in a week's time. Otherwise the trend and grouping did not change significantly.

End Coating. The effect of end coating is shown in Fig. 7. Again a few softwoods are closely grouped, while Ponderosa pine continues at a higher rate, as before. The average rate appears to be about one-half pound less in seven days, as compared with uncoated ends. Apparently the shellac end coating did reduce the absorption, but not critically. It also appears that the end coating began to soften after 20 or 30 hr, allowing some end penetration of oil, as each curve began to show a reversal of curvature and a rising tendency. Thus it may not be economical to go to the trouble of end coating when several days of soaking are required.

Equations for Predicting Absorptions. Fig. 8 shows three typical curves, as plotted for white fir, comparing incising and end coating. These curves show the usual result of such treatments. The equations were found by plotting the data on log-log paper, to determine coefficients and exponents. If H is hours of soaking time and A is absorption in pounds per cubic foot of wood submerged, then it generally appears that $A=C_1+C_2H^n$, where C_1, C_2, and n depend upon species of wood, type of treatment, and condition of posts. The value of C_1 apparently depends principally upon the type of treatment, as the other constants are more nearly equal. The end coat equation, however, has the highest value of n, the exponent, which may result from the softening and permeation of the shellac end coat by the treating oil, and a higher rate of continued absorption.

Brush and Spray Treatments. Results of the one-brush, two-brush, one-spray, and two-spray treatments are shown only in Fig. 9. These absorption rates are all very low, as must be expected, and suggest a much poorer protection than the other treatments, also shown in Fig. 9. Inasmuch as the treatment is applied to the most critical region, near the ground line, and no oil is wasted on other areas, particularly at the butt end, it is hoped that these methods will prove effective, and a few years time in the test plot should produce some interesting data.

Effect of Wood Structure. Important differences appear in the absorption rates among the different species and between hardwoods and softwoods. With the one exception of Monterey pine, the hardwoods, eucalyptus, and tamarix absorbed the preservative in greater amounts and more rapidly than did the softwoods. This variation is related to fundamental differences in wood structure. The sapwood of hardwoods contains relatively large, open tubes called

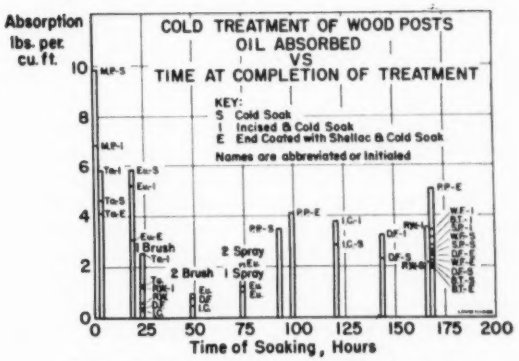

Fig. 9 Graphical summary of absorption data

vessels through which preservatives can move rapidly in a longitudinal direction. The sapwood of conifers, on the other hand, does not contain these vessels, and liquid preservatives must pass from cell to cell through minute "pit" openings in cell walls. On this basis alone absorption is slower. Absorption may be retarded even more when these pits become clogged or closed by portions of the cell wall. It is known that a high percentage of the cell wall pits in Douglas fir are so closed. The very slow absorption rate of the Douglas fir and some other species in this study may be due to this cause.

Nearly all groups of incised posts absorbed more rapidly than cold-soaked groups. Most end-coated posts absorbed less than either the incised or the cold-soaked group. These differences are related to wood structure. The cells and vessel openings through which the preservative passes are aligned longitudinally. Normally lateral movement across these elements is very slow while longitudinal is relatively rapid. Incising posts creates lateral openings which exposes more cell ends thus facilitating longitudinal absorption. End coating closes the exposed cell openings thus reducing the rate of absorption.

Close observations on the absorption characteristics of Monterey pine posts showed a peculiar relationship between surface pitch coating and absorption rate. Six of the posts were peeled green and developed a definite pitch coating during seasoning. Those peeled dry did not develop such a coating. The pitch-coated posts absorbed an average of only 2.6 lb per cu ft in a one-hour period; the non-pitch coated, 9.8 lb per cu ft in one hour.

SUMMARY

1 There is a wide range of absorption rates among different species of wood.

2 The sapwood of hardwoods generally absorbs treatments more rapidly than sapwood of softwoods, because of their physical nature, although some softwoods also have high rates of absorption.

3 Incising should be expected to increase absorption, although vigorous incising can be harmful to the stake or post, and durability may not actually be improved.

4 End coating will usually decrease the amount of absorption, although the rate will increase after the coating is softened or dissolved.

5 Absorption rate is always high at first, decreasing with time, on a parabolic type of pattern. It may be represented fairly well by an equation *(Continued on page 544)*

Irrigation Period Factor in Sprinkler Irrigation Design

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ASSOC. MEMBER ASAE

APPLICATION of sprinkler irrigation has increased by leaps and bounds in the last eight years. With more acres coming under irrigation and more equipment being sold, the proper design of an irrigation system is becoming increasingly important. A fundamental part of irrigation design is the fact that irrigation water should be applied to an area before the crop shows signs of water deficiency. It is especially important in the eastern part of the United States, where natural rainfall does not permit development of irrigation cycles, that irrigation systems must be designed with a capacity large enough to irrigate a designated area before the moisture content of the soil reaches the permanent wilting point.

It is the author's intent in this paper to clarify this one design factor, the irrigation period. Especially in areas of non-cyclic irrigation, this factor has been confused with frequency of irrigation, with improper design as a result.

An irrigation period is the number of days required for operation of an irrigation system to adequately irrigate a designated area. "Irrigation period" is not necessarily synonymous with "frequency of irrigation," which is the elapsed time in days from the start of one irrigation to the start of the next. Irrigation period is always used in the design of irrigation systems; it is the factor F (days of operation) in the equation $Q=453Ad/FH$, to determine system capacity.

Design Objective. Part I, section 2(b) of the ASAE Recommendation: Minimum Requirements for the Design, Installation and Performance of Sprinkler Irrigation Equipment" states, "For supplemental irrigation and/or special uses, the system shall have the capacity to apply a stated amount of water to the design area in a specified net operating period." Except during frost control, this net operating period usually exceeds one day, because of physical and economic limitations. As the net operating period increases, the system capacity and amount of portable equipment will decrease. Thus one of the objectives of proper design is the determination of the *maximum* safe net operating period.

Present Design Example. Consider first a design in which the "irrigation period" is synonymous with "frequency of irrigation." For some crops under supplemental irrigation practice, it is considered desirable to start irrigating when the available water in the root zone has been reduced to the 50 percent level. The irrigator will start irrigation at one end of the field and restore the moisture content of the root zone at that end to field capacity (100 percent available moisture).

Thus the first normal step in sprinkler design is the determination of the depth of water to apply at each irrigation. This depth depends on the available water-holding capacity of the soil and the normal root depth of the crop in that soil.

Throughout the remainder of this paper it is assumed that this first step has been completed, and that the soil in the following examples has a total available moisture capacity of 4 in in a 2-ft root zone. Then, to replenish 50 percent of the available moisture, 2 in of water will be applied, usually to the entire area.

The second usual step in the design is to divide the peak evapotranspiration use rate into the inches of water in the 50 percent available moisture to be restored, thus obtaining the frequency of irrigation in days. In this example, if the peak use rate is 0.2 in per day, the frequency of irrigation is then 2 in $\div$ 0.2 in $=$ 10 days. This quotient has been mistakenly used as the irrigation period – the time (in days) allowed to cover the entire field.

Because this irrigation period is based on replenishment of 50 percent of the available moisture, and the irrigation is started at 50 percent available moisture remaining, the moisture content in the "finishing" end of the field will decrease by about 50 percent of the available moisture before the portable system is in position to irrigate this area. Thus the moisture content of the soil in this portion of the field will drop from 50 percent available moisture to 0 percent available moisture (the wilting point) in the time allowed to cover the entire field. Fig. 1 illustrates the results of this practice.

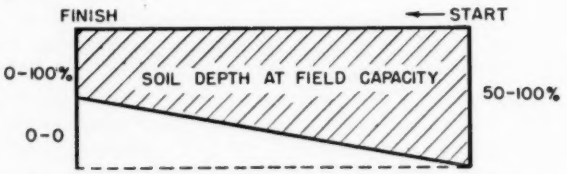

Fig. 1 This illustrates the sprinkler irrigation design practice described in the accompanying paper.

At the starting end of the field, the 2-in application will bring the entire root zone back to field capacity. Now, because in this example the irrigator uses an irrigation period equal to the frequency of irrigation of 10 days, he will probably irrigate one-tenth of the total area each day. After nine days of irrigating, which would cover nine-tenths of the area, the last one-tenth or "finishing" end of the area will have reached (2 in $-$ 9 $\times$ 0.2 in) $\div$ 4, or 5 percent available moisture. On the tenth day, the moisture content of this part of the field would vary between 5 and 0 percent available moisture.

The 2-in application at this end of the field will then bring the moisture content of only the first foot of the root zone up to field capacity. Thus not only has the moisture content in this end been allowed to drop to the wilting point, but the depth of water applied is only one-half the amount needed to restore the entire root zone to field capacity, leaving the lower foot of the normal root zone close to the wilting point.

Effects in Arid Areas. In arid areas, irrigation cycles are sometimes developed by applying increasing amounts of

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The author—John R. DAVIS—is instructor in agricultural engineering, Michigan State College.

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water from the starting to the finishing end of the field during the first irrigation. Thus instead of an application of 2 in over the entire field, a variation between 2 in at the starting end and 4 in at the finishing end would be applied. Then the entire field is set up for cyclic irrigation, such that on each day during a following irrigation, a 2-in application will bring the moisture content of the root zone from 50 percent available water to field capacity.

If this measure is not taken, however, and the irrigation period is again assumed to equal the irrigation frequency during the second irrigation, the moisture content of the top one foot of the root zone in the finishing end would vary from 0 percent available moisture to field capacity.

Effects in Humid Areas. Natural rainfall in humid and semihumid areas occurs sporadically throughout the crop-growing season. There will be times when rainfall will bring the moisture content of the bulk or all of the root zone back to field capacity, and the entire field will be at the same moisture content (neglecting soil differences). Thus cyclic irrigation usually cannot be developed, other than in years of extreme drought, and the irrigator will normally apply water several times during the season under the same set of conditions as the first irrigation of the season.

Using frequency of irrigation synonymously with irrigation period in humid areas could then result in allowing the moisture content at one end of the field to dangerously approach the wilting point. This might occur not only once, but twice, or even three or more times during a normal growing season.

Most irrigators derive maximum benefits from irrigation when the moisture content of the root zone remains above the wilting point. Many eastern irrigators even prefer to start irrigating such that the moisture content in the field never drops below 30 to 50 percent available water. Thus benefits of irrigation would be lessened considerably if the moisture content of the soil in part of a field was permitted to be reduced to the wilting point several times during the season. Primarily for this reason the following design procedures are suggested:

Suggested Design No. 1. To prevent the moisture content of the soil in the "finishing" end of the area from dropping to the wilting point, an irrigation might be started when the soil moisture content is at 60 percent available moisture. The amount of water applied will then be 40 percent of the available moisture capacity, or 1.6 in if applied to the previous figures. The moisture content of the "starting" end of the area will then vary from 60 to 100 percent available moisture and the "finishing" end would drop to only 20 percent available moisture. This practice would not allow the moisture content of any portion of the area to drop to the wilting point. The frequency of irrigation would be 1.6 in ÷ 0.2 in, or 8 days, which is a 20 percent shorter time than the previously-figured 10-day frequency. In this example, both the frequency of irrigation and the irrigation period have an equal number of days.

The system capacity would be the same as in the previous design. Only the operating procedure would be changed. Labor costs would be higher, however, for the pipe lines would be moved more often during the season.

Suggested Design No. 2. Perhaps a better design would allow for a time differential between frequency of irrigation and irrigation period, permitting maintenance and repair of the system and also time off for labor. To accomplish this, the irrigation period must be of shorter duration than the frequency of irrigation. Using this design, the irrigation would be started when the moisture content of the field reached 50 percent available moisture and would be completed before the last part of the field reached 10 percent available moisture.

Thus the amount of water applied would be 50 percent × 4 in = 2 in. If 10 percent available moisture (10 percent × 4 in = 0.4 in) is to remain at the "finishing" end of the field, the application must be completed before 2.0 − 0.4 = 1.6 in is depleted. The period of irrigation in this example is then 1.6 in ÷ 0.2 in or 8 days to cover the entire field during the first irrigation, and the frequency is 10 days between successive irrigations.

Suggested Design No. 3. As stated previously, system capacities and amount of equipment are at a minimum when the irrigation period equals the frequency of irrigation. Sprinkler irrigation recommendations for Michigan formulated by U.S. Soil Conservation Service and Michigan State College personnel are based on starting irrigation for most crops at 55 percent available water. Thus 45 percent is replaced, and if irrigation period is equal to irrigation frequency, the moisture content of the "finishing" end will drop from 55 percent to 10 percent available moisture.

The frequency of irrigation is (100 − 55 percent) 4 in/0.2 in = 9 days, and the irrigation period is (55 percent − 10 percent) 4 in/0.2 in = 9 days. The system capacity would be the same as for design No. 1 and the example of present design. The area must be irrigated in 9 days, and the moisture content of the "finishing" part of the field will drop to only 10 percent available moisture.

Suggested Design No. 4. In arid areas where irrigation cycles are possible, one might start the first irrigation by applying increasing amounts of water from the "starting" end to the "finishing" end of the field, such that the moisture content in the entire root zone at the "finishing" end is brought back to field capacity. In this manner, the entire field would vary from 50 to 100 percent available moisture throughout the season. The irrigator should be cognizant of the fact that the first irrigation would take a longer time to complete, and there may be some danger of exceeding the time of "frequency of irrigation."

SUMMARY

Table 1 summarizes the examples cited previously. Perhaps the best possible design would be suggested design No. 3, in which irrigation is started at 55 percent available moisture and the irrigation period is equal to the frequency of irrigation. Not shown in the table are comparisons of labor and equipment, however, which are instrumental in the design of a system. Design No. 1 would necessitate higher labor and possibly more *(Continued on page 544)*

TABLE 1

Design	Range of moisture content—"starting" end percent available moisture	Frequency of irrigation, days	Irrigation period, days	Lowest moisture content of "finishing" end, percent available moisture	Comparative system capacity
Present	50-100	10	10	0	100
Suggested No. 1	60-100	8	8	20	100
Suggested No. 2	50-100	10	8	10	125
Suggested No. 3	55-100	9	9	10	100

Allowable Bending Mome

Maurice
STUDENT ME

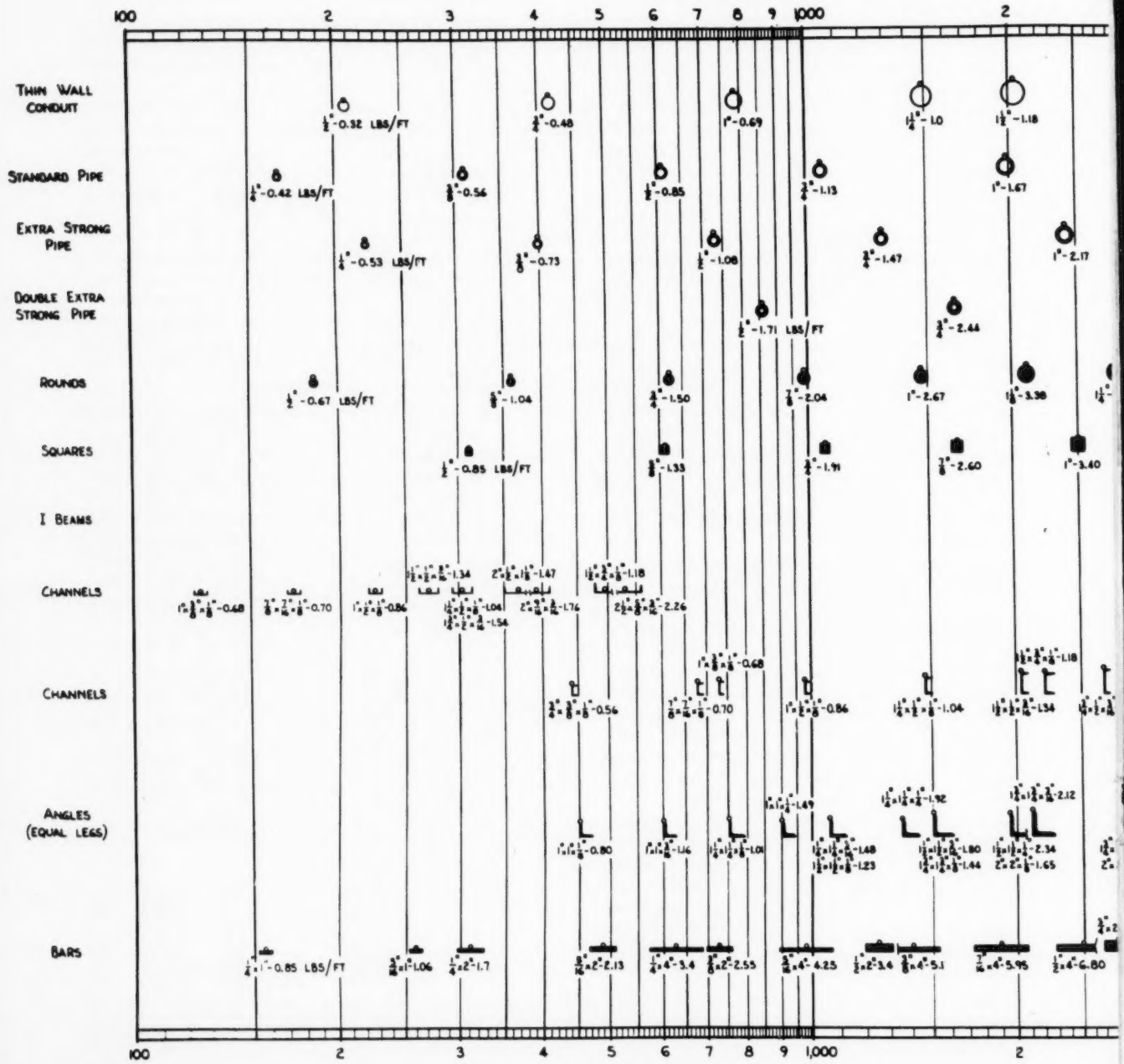
THE accompanying chart shows the allowable bending moment for structural members of different sizes and cross sections. It should be useful to engineers and shop men, not only in determining the proper size of a member of given cross-sectional shape, but also in the rapid comparison of the strengths of commonly used structural shapes. Weight data are included for added convenience.

The allowable bending moments were calculated from the equation, $M=SZ$, using an allowable stress of 15,000 psi, where

This paper was prepared expressly for AGRICULTURAL ENGINEERING.

The author — MAURICE JOHNSON — is a 1953 graduate in agricultural engineering from the University of California.

ALLOWABLE BENDING MOMENT IN INCH-POUNDS (B



ent for Structural Members

Johnson
MBER ASAE

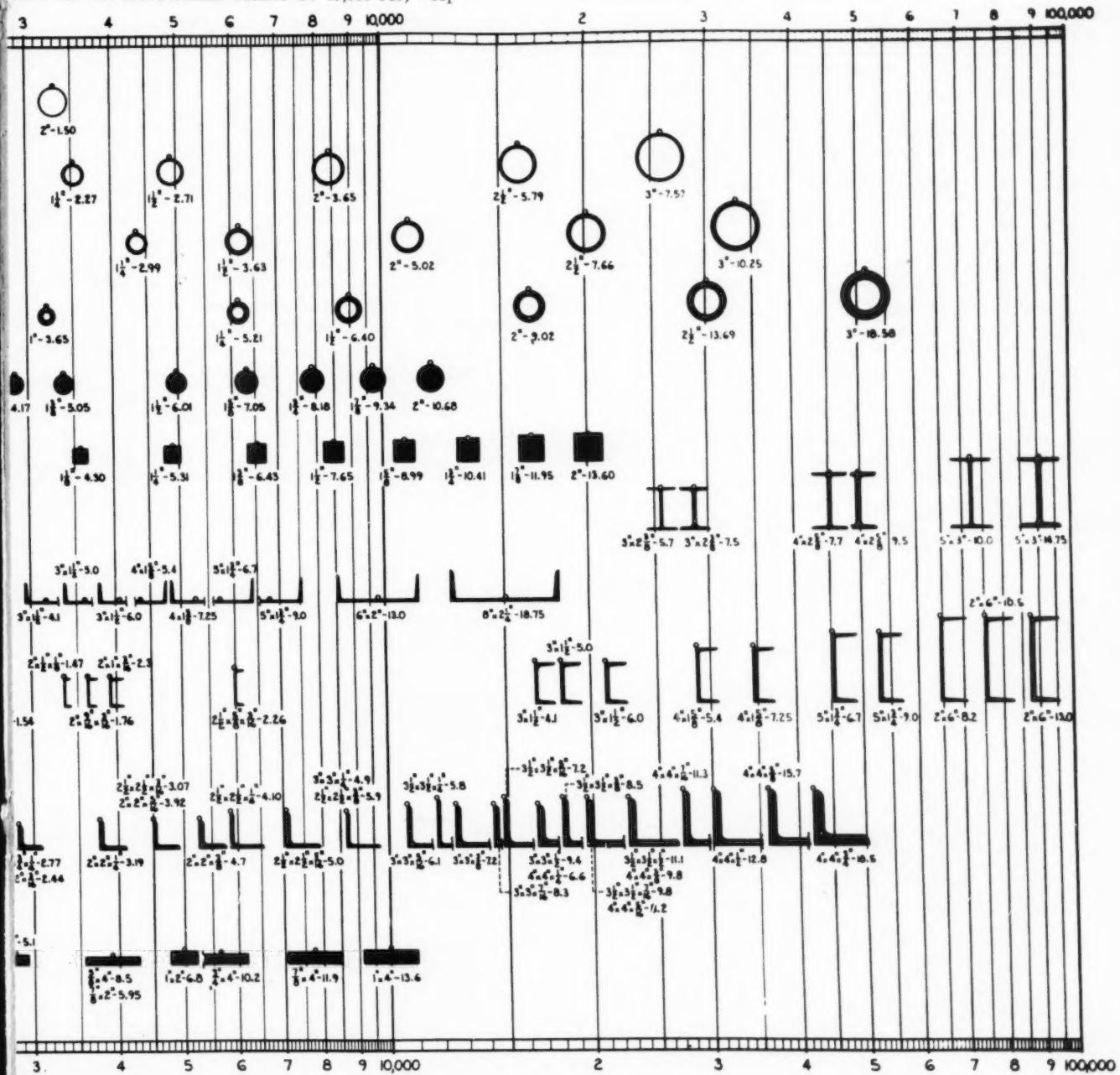
M = allowable bending moment
S = allowable stress
Z = section modulus.

For SAE 1020 steel or equivalent, this gives a factor of safety of about two if based on the elastic limit, and four if based on ultimate strength. Other allowable stresses can be used by applying the following adjustment:

$$M_2 = \frac{S_2}{15{,}000} M_1$$

where S_2 = new allowable stress
M_2 = allowable bending moment for S_2.

ASED ON AN ALLOWABLE STRESS OF 15,000 PSI) = M_1



Measuring the Forces in Tractor Linkage

I. C. Rogers and G. M. Johnston

SINCE 1937, there has been an ever-increasing number of implements mounted integrally with the farm tractor. There are many advantages in this type of mounting, such as maneuverability in the field and in transport, but the forces in the links and their effect on the implement and the tractor are relatively unknown. This paper describes an instrument for measuring the dynamic forces in a tractor linkage connecting the mounted implement to the rear of the tractor.

The project was undertaken to investigate the forces in the linkage used on a two-plow tractor and a mounted plow. For a selected soil condition, the magnitude of the forces and the amount and rate of their fluctuations were recorded. From the recorded data, the weight transfer to the rear wheels of the tractor was calculated. As further test data are accumulated, graphs will be made indicating the way that the forces in the individual links vary for different soil conditions.

The standard linkage system was unaltered except that hydraulic cylinders were placed in the links (Figs. 1 and 2). Each link had a single-acting hydraulic cylinder attached to a Bourdon pressure gage by a flexible hose. All the gages were mounted on a gageboard in a cluster arrangement so that they could be photographed simultaneously by a 16-mm movie camera. Each pressure gage was calibrated with its respective cylinder to read, directly in pounds, the force applied to the ends of the link. Since it was necessary to maintain the same geometric dimensions between the test linkage and the standard linkage, small amounts of oil had to be added or removed from each cylinder. A lever-type grease gun was used successfully to introduce oil through a standard grease fitting in each oil line.

The depth of plowing was indicated by means of a gage wheel which measured the relative vertical distance between the sole of the rear plow and the ground surface immediately next to it. The gage wheel ran about one foot behind the center of resistance of the plow and about four inches away from the sliding landside, to operate on unbroken ground. The vertical motion of the gage wheel was transferred to the gage board, where the actual depth of plowing was indicated on a dial. Because of the displacement of the center of the gage wheel behind the center of resistance of the plow, there was a time lag in the depth readings for the forces shown. Correction was made for this delay when taking the data from the films. When the camera and dials are replaced by a synchronized drum recorder, it will be easy to make this correction. The accuracy of the depth gage was $\pm 1/16$ in on level ground. For a single depth reading across the width of the plowed furrows to be significant, the ground should have a smooth surface.

The camera was mounted on the frame of the gage board about three feet to the rear of the dials, to take a record of all the gages at one time. A rear-vision mirror was attached to enable the operator of the tractor to see the depth gage and so regulate the tractor controls to give a desired depth of plowing. Since the cylinders were single acting, a tie chain was required on the top compression link to support the plow in transport position.

Tests were conducted to establish the over-all accuracy of the instrument, by installing a strain gage in a chain connecting the back of the plow to an anchor post. Compared to the corrected strain-gage readings, the error in the instrument was four per cent. This error is mostly attributable to the friction in the cylinders. The arrangement of the dials is shown in Fig. 2, and the connections from the cylinders in the links of the gages in Fig. 3. The forces in the two bottom links were tension, while that in the top link was compression.

The necessary adjustments were made to the plow to obtain the correct width of cut of the front bottom and the level of the two bottoms so that even depth of furrows were obtained. The length of each link was measured and ad-

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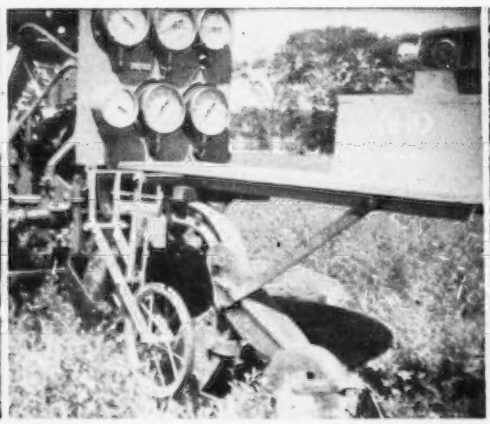


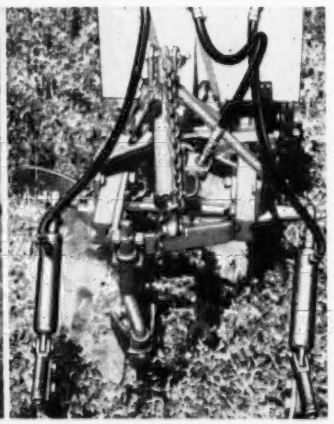


Fig. 1 *(Left)* General arrangement of the tractor, mounted plow, and gage board • Fig. 2 *(Center)* Mounted plow and linkage with the gage board attached. The gage dials are — top row, left to right — for left-bottom, top, and right-bottom links. The left-bottom dial is for the depth indicator, and the other two dials were for other equipment • Fig. 3 *(Right)* Front view of the gage board on the plow

justed to its correct value by adding or bleeding oil from the lines. The over-all depth control was obtained by shortening the top link to increase the depth or lengthening it to decrease the depth. A floating type of linkage was used, that is, the plow finds its own level while in motion. If the plow tends to go deeper, the linkage changes the angle of attack and the plow noses up until equilibrium is reached. The connecting rods hold each of the bottom links at a fixed horizontal position with respect to each other. The angles of the links were found by setting the plow at various depths and measuring the respective angles with a level protractor. Both the angles in the horizontal and vertical plane were measured.

A test section about 300 ft long was used for the tests with a 100-ft section in the middle being used to record the readings. The remainder of the section was used to obtain uniform operating conditions and to make adjustments before the test run. Pictures were taken at the rate of sixteen frames per second. The speed of plowing was found by using a stop watch over the measured distance of 100 ft.

Calculations and Data. The static weight of the tractor used in this experiment was 3100 lb. It had a wheelbase of 76 in, with the center of gravity 26 in ahead of and 6 in above the center line of the rear axle. This will give a static weight of 2040 lb on the rear wheels and 1060 lb on the front wheels.

The tractive reaction was assumed to be at a point 2 in ahead of the center of the rear axle. The tread width was 48 in, center to center of the rear tires.

Abbreviations used are as follows:—

LBL—Left bottom link
RBL—Right bottom link
TL—Top link
R_o—Static reaction of rear wheels
*R_1—Dynamic reaction of rear wheels
R_2—Reaction of front wheels
F—Force

*Dynamic reaction refers to the effective weight on the rear wheels of the tractor when it is pulling a drawbar load. It consists of the weight from the tractor and the plow plus the vertical forces from the plow.

Subscripts:

t—top link
b—bottom link
h—horizontal component
v—vertical component

Link	Vertical angle, α	Horizontal angle, β	Correction factor	Measured force	Components horizontal	Vertical
LBL	−7 deg	−20 deg	0.930	1370 lb	1274 lb	156 lb
TL	+5 deg	−6 deg	0.990	1230 lb	1218 lb	107 lb
RBL	−2 deg	+4 deg	0.996	1235 lb	1230 lb	43 lb

Drawbar pull $= F_{bh} - F_{th} = 1274 + 1230 - 1218 = 1286$ lb

Weight transfer to the rear wheels as R_1:

$$\Delta R_1 = \frac{F_{bh}Y_2}{X_0'} - \frac{F_{th}Y_1}{X_0'} + \frac{F_{bv}(X_0+X_3)}{X_0'} + \frac{F_{tv}(X_0+X_2)}{X_0'}$$

$$= \frac{2500\times 20.0}{74} - \frac{1220\times 34.9}{74} + \frac{200\times 85.9}{74} + \frac{107\times 87.6}{74}$$

$$= 675 - 576 + 232 + 127 = 458 \text{ lb weight transfer}$$

$$\text{Dynamic reaction on rear wheels } R_1 = \frac{W(X_0 - X_1)}{X_0'} + \Delta R_1$$

$$= \frac{3100(76-26)}{74} + 458 = 2558 \text{ lb}$$

$$R_{1R} = R_1 \times (Z_2/Z_1) = 2558 \times 27.5 \div 47.5) = 1480 \text{ lb}$$

$$R_{1L} = R_1 \times (Z_3/Z_1) = 2558 \times (20.0 \div 47.5) = 1078 \text{ lb}$$

Assume that one-half the pull was taken by each wheel.

Tractive force $= 1286/2 = 643$ lb

Required coefficient of traction on right wheel $= (643 \div 1480) = 0.435$

Required coefficient of traction on left wheel $= (643 \div 1078) = 0.587$

Fig. 6 is a graph of the recorded values of the various forces.

The camera was set at 16 frames per second and the speed of plowing was approximately 2 mph. This gave a reading of the forces for every 2 in of travel. It is interesting to note the relationship between the forces. In general,

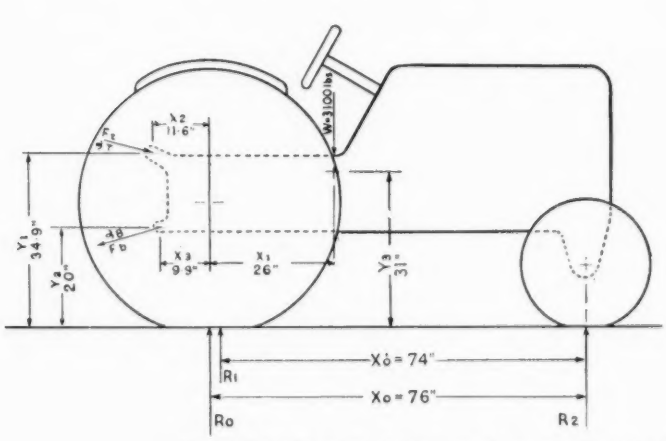
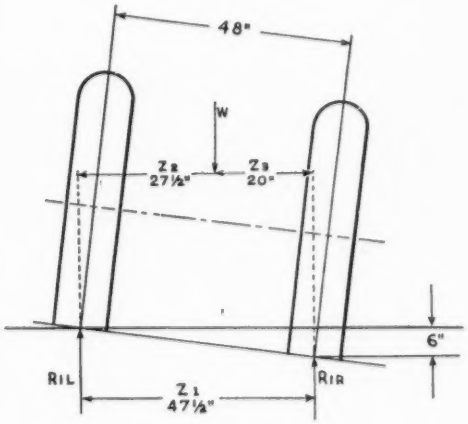


Fig. 4 *(Left)* Diagram of side view of tractor • Fig. 5 *(Right)* Diagram of rear view of tractor



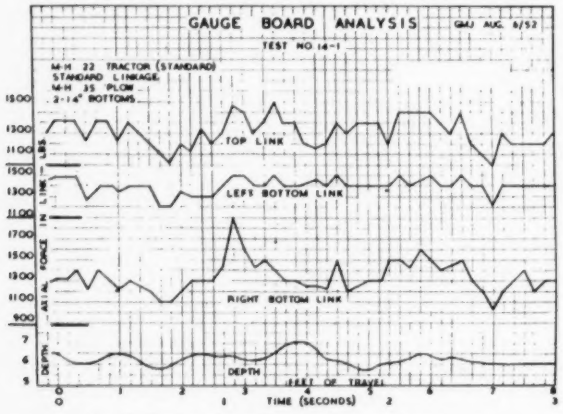


Fig. 6 Graph of readings from a gage-board test

an increase in draft causes an increase in the forces in all the links. The compressive force in the top link is equal to the average of the tension forces in the two bottom links. The center of resistance of the plow would be about 3 in above the sole.

It appears from this graph that the right bottom link will be subject to the greatest shock loads.

The average forces in the respective links were:

Left bottom, 1380 lb Top, 1298 lb Right bottom 1326 lb

Maximum variations in forces were:

LBL—300 lb	—13 percent and +9 percent
TL—600 lb	—23 percent and +23 percent
RBL—900 lb	—25 percent and +43 percent

Therefore the per cent variation of the top link is about equal to the average variation in the left and right bottom links but the force variation in the right bottom link is about three times that in the left.

Tractor drawbar pull is dependent upon the weight acting on the traction wheels. For different surface conditions the percentage of drawbar pull to the weight on the rear wheels varies greatly and 60 per cent is a high value for field use. As shown by the results presented in this paper, the effective increase in traction in plowing is dependent on the weight transferred to the left rear wheel of the tractor. From this information it may be possible to improve the ratio of the required tractive coefficients between the two rear wheels.

Resistance strain-gage pads could be used with a six-channel recorder to evaluate the forces in the members of the linkage. More accurate readings would be possible than with the gage board, and the recorder could be calibrated to give direct readings of the forces. For any changes in the test section of the links the recorder would require recalibration or the readings would have to be corrected.

The drawbar pull of the tractor was about equal to the algebraic sum of the linkage forces since the top and bottom links were nearly parallel to the ground surface. The normal variation in the link forces was about ± 25 per cent which indicates how rapidly the soil resistance to the plow changed in an average field.

Relugged Tractor Tires

(Continued from page 533)

flexible than the ones on the tire that had been used for other tests in the series.

DISCUSSION

A careful examination of tires at the end of the tests on the V bars showed that none of the lugs on the new or recapped tires were torn loose. Three or four of the lugs on the relugged tire showed slight separation of the weld at the outer end of the lugs. These separations could not be called failures, however.

The severeness of the test to this point in the series was thought to be equal to or above that which might be expected in normal service. Since no lug failures had occurred thus far, tests on the ¾ x ¾ x 2½-in steel bar were made. In this series of tests the steel bar tended to cut and tear the front side of the lugs. All lugs were badly cut. This test caused the separation failures on about 90 percent of the lugs of the relugged tire. However, the separation did not occur until the steel bar had cut through the front edge of the lug. The torture on these lugs was thought to be greater than would normally occur in the life of a farm tractor tire.

The results of these tests indicate that sound tractor tires, properly relugged, will be effective and will give satisfactory service with marked savings in rubber.

Wood Absorption Rates

(Continued from page 537)

of the type: $A=C_1+C_2H^n$, where A=absorption in pounds per cubic foot, and H=hours of time.

6 Many softwoods have such low rates of absorption that a full week is required to attain a serviceable amount of oil penetration.

7 Pitch coatings on some posts, due to peeling bark when green, may seriously reduce the rate of absorption.

Sprinkler Irrigation Design

(Continued from page 539)

equipment than design No. 3.

Agricultural engineers and soil scientists have developed accurate and practical instruments to determine soil moisture. Moisture blocks and tensiometers are becoming more widely used. In the last decade, formulas for determining evapotranspiration of plants have been developed, and have resulted in the adaptation of a moisture-balance method of determining when to irrigate.

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Corrosion of Aluminum Alloy Grain Bins

George A. Ellinger and Fred M. Reinhart

WHEN the U.S. Department of Agriculture undertook the grain storage program in 1939 galvanized steel and wood were the two materials used. Galvanized steel was reasonably satisfactory for this service and little difficulty was encountered with corrosion. However, in 1948 and 1949 this material became difficult to obtain and the use of other material became necessary. Aluminum alloys were suggested and late in 1949 grain was first stored in round bins of about 3,300-bu capacity made of these materials. Fig. 1 shows a typical bin site.

Almost a year later holes were found in the sidewalls of the round bins at several storage sites. Subsequent inspection of a site near Harrisonville, Mo., by K. B. Huff of the University of Missouri, revealed that several bins had been severely corroded, necessitating the replacement of some sheets. Examples are shown in Figs 2 and 3.

The most severe corrosion occurred on the bottom sheets. Most of these were damaged to some extent, it being necessary to replace completely two bottoms and to replace some sheets in others. All of the corrosion was on the inside surface of the sheets. The outside, or bottom, surfaces of these sheets had been coated with an asphalt paint during erection and no corrosion was found on these surfaces.

Most of the corrosion and penetration of the sidewall sheets occurred in the lower ring but some was also found in the second and third rings. In all cases corrosion of the sidewalls occurred near joints, either vertical or horizontal.

Fumigants did not appear to play a serious part, since corrosion was found in bins in which the corn had not been treated as well as those in which it had been. There was, however, an apparent relationship between the rotted corn and corrosion, since it was always found in the corroded areas. It was observed that the severely corroded areas were covered with dried rotted corn, but in the areas where the rotted corn was wet the aluminum was stained but not seriously damaged.

The moisture content of the corn in the bins was not excessively high. The average for all of the round bins at this site for the period during which the damage occurred was 9.7 percent. The maximum content in any of the damaged bins during this period was 11.7 percent. Since 12.0 percent moisture content is considered to be safe for long-time storage, that of the corn in the damaged bins could be considered to be quite satisfactory.

Since there was an apparent relationship between dried rotted corn and the corroded areas, it is obvious that moisture must have originally played an important part in the corrosion of the aluminum. The corroded areas of the side sheets and the rotted corn were localized near seams, through which water could have leaked. This appears to be a reasonable explanation for the localization of the corrosion. There also appeared to be some evidence that ground water entered some of the bins.

Because of the rapid deterioration of the aluminum alloys in some of the bins the National Bureau of Standards was requested by the Division of Farm Buildings and Rural Housing (BPISAE), U.S. Department of Agriculture, to conduct a two-fold investigation to determine (1) the nature and cause of the corrosion of the aluminum alloy sheets in the damaged grain bins, and (2) the effect of various liquid fumigants on several aluminum alloys which might be considered for use in the construction of grain bins for the Commodity Credit Corporation.

CORRODED GRAIN BINS

Sheets from four damaged aluminum alloy grain bins from the Harrisonville site were submitted for examination. These bins were of the same design, 18 ft in diameter and 16 ft high, made by the same manufacturer and installed at the same time, in the fall of 1949. The locations of the

This paper was presented at the winter meeting of the American Society of Agricultural Engineers at Chicago, Ill., December, 1952, as a contribution of the Farm Structures Division.

The authors—GEO. A. ELLINGER and FRED M. REINHART—are, respectively, chief and metallurgist, corrosion section, National Bureau of Standards, U.S. Department of Commerce.

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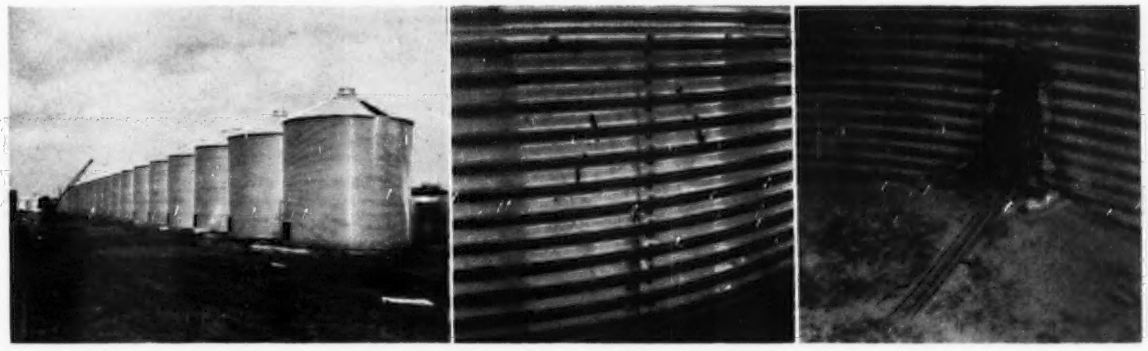

Fig. 1 *(Left)* A typical grain storage bin site • Fig. 2 *(Center)* Holes in sidewall of grain storage bin caused by corrosion from the interior • Fig. 3 *(Right)* Interior of grain storage bin showing corrosion of lower ring sheet and floor (Photos courtesy U.S. Department of Agriculture)

sheets in the bins and their compositions are given in Table 1.

The corn in two of the bins had been treated with fumigants on July 18 and 19, 1950. The fumigant used in bin 89103 was chloropicrin applied at the rate of 2.5 lb per 1000 bu of grain, while that used in bin 89092 was the following mixture applied at the rate of 5 gal per 1000 bu of corn:

Ethylene dichloride	18.3 percent
Carbon tetrachloride	24.1 "
Ethylene dibromide	57.6 "

The corn in bin 89101 was not treated during storage while the treatment in bin 89102, if any, is not known.

Table 1. Chemical Composition of Grain Bin Alloys as Determined by Spectrochemical Analysis

Bin Number	Location	Thickness inch	Chemical Composition - Percent									ASTM Type Alloy	Commercial Type Alloy
			Cu	Si	Fe	Mn	Mg	Cr	Zn	Ni	Ti		
89092	Side	0.065	0.17	0.18	0.62	0.09	L0.04		-(0.05)	-(0.057)	0.03	990A	2S
89092	Side	.065	.3	.2	.8	.1	.4	0.03	-(0.1)	-(0.05)	.04	990A	2S
89092	Side	.065	.18	.18	.6	.09	L0.04		-(0.05)	-(0.057)	.03	990A	2S
89092	Floor	.032	2.4	1.1	1.1	1.0	.6		.6	L0.10	.02	a	b
89101	Floor	.032	2.3	1.5	1.1	.4	.8	.07	.6	.1	.02	a	b
89102	Floor	.032	2.4	1.2	1.2	1.0	.6		.6	L0.10	.02	a	b
89103	Floor	.032	2.5	1.4	1.1	.4	.9	.08	1.1	.1	.03	a	b
89103*	Floor	.032	2.5	1.1	1.0	.86	.65		1.0	.08	.025	a	b
89103	Side	.065	.2	.1	.5	1.1	1.1	-(.01)	-(.1)	-(.05)	-(.01)	MG11A	4S
89103	Side	.065	.15	.13	.52	1.10	1.09		-(.05)	-(.05)	-(.01)	MG11A	4S
89103	Side	.065	.14	.13	.51	1.08	1.08		-(.05)	-(.05)	-(.01)	MG11A	4S
89103	Side	.065	.14	.13	.50	1.08	1.08		-(.05)	-(.05)	-(.01)	MG11A	4S

* The results on this material were checked by chemical analysis.
L means "less than"
- means not detected; the limit of detection is given in parenthesis.
a No ASTM designation for this material; no wrought sheet alloy with such a chemical composition listed in any data books of the various aluminum producers in this country.
b No commercial designation for alloy of this composition.

Sidewall sheets from two bins, 89092 and 89103, were examined. Chemical analyses of these sheets indicate that those from bin 89092 were made of commercially pure aluminum alloy 2S, ASTM designation 990A, while those from bin 89103 were made of alloy 4S, ASTM designation MG11A.

Corrosion of the sidewall sheets from both bins was similar. The sheets were penetrated at or near joints, typical examples of which are shown in Fig. 4 to 9. A vertical section of a bottom-ring sidewall sheet showing the bolt holes and floor flange is shown in Fig. 4. When this bin was inspected by Mr. Huff after it was emptied, the corn between the perforations and the bolt holes was wet while that at the perforations was caked and rotted. The assembled vertical joint in Fig. 5 shows distinct evidence that the corn on both sides of the joint had been wet and the pattern of corrosion suggests that rain water may have entered open seams. Mr. Huff's inspection of the emptied bins at the site indicated that corrosion of the side sheets in all cases was confined to areas along either vertical or horizontal seams. A severely corroded and perforated side sheet is shown, somewhat enlarged, in Fig. 6. This gives a better idea of the localized nature of the corrosive attack.

Aluminum and its alloys depend upon a thin oxide film to provide protection against corrosion and as long as that film is unbroken the metal will not corrode. The accompanying illustrations show that the aluminum was discolored and attacked to some extent over the entire area in contact with the wet corn but that severe attack and perforation was localized at the interface between the wet and the dry corn. This observation indicates that the corrosion was brought about by electrolytic action which rendered the aluminum at the interface anodic in character because of the destruction of the oxide film. Two factors may have contributed. Oxygen of the air may have been partially excluded from the wet zone thus setting up the same kind of a difference of potential between the wet area and the margin as that which is responsible for the well-known water-level corrosion. Another contributing factor may have been the migration of acids, carbohydrates, and other decomposition products of the corn to the interface. This migration could readily have been brought about by the repeated entry of rain water and its evaporation at the interface.

Similar localized corrosion is shown in Fig. 7 which is a photograph of a portion of the flange section of a bottom

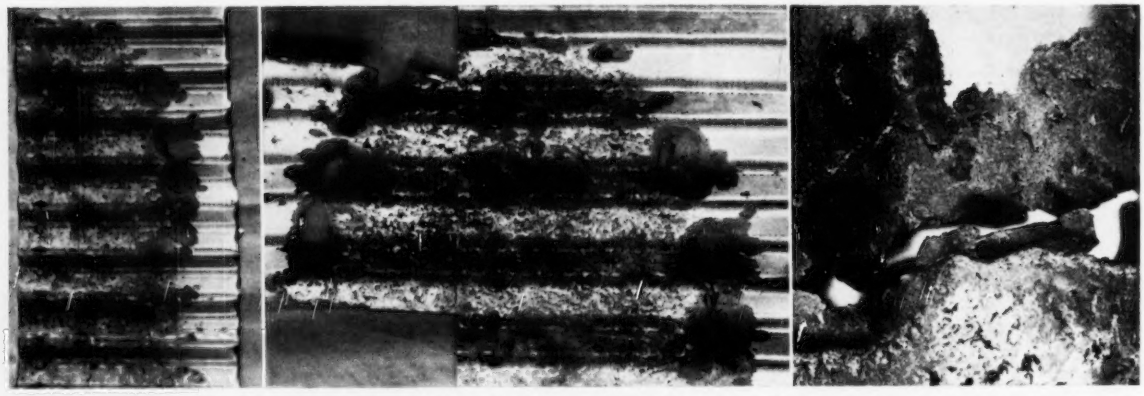

Fig. 4 *(Left)* Vertical joint in bottom ring of grain bin 89092. Bottom flange is at bottom. Note areas of corrosion and perforation along outer edge of area where corn was wet. Wet corn was in the discolored area between the vertical row of holes and the perforations on the right • Fig. 5 *(Center)* Two pieces of bottom ring bolted together to show relationship of perforations to the vertical joint. Section shown is at top of area of wet corn along vertical joint • Fig. 6 *(Right)* Severely corroded and perforated area at periphery of wet corn in side sheet shown in Figs. 4 and 5 at higher magnification to show localized nature of the attack. Stained area at bottom was covered with wet corn while the uncorroded area at the top was covered with dry corn. Caked, rotted corn which was partially dry covered the corroded areas

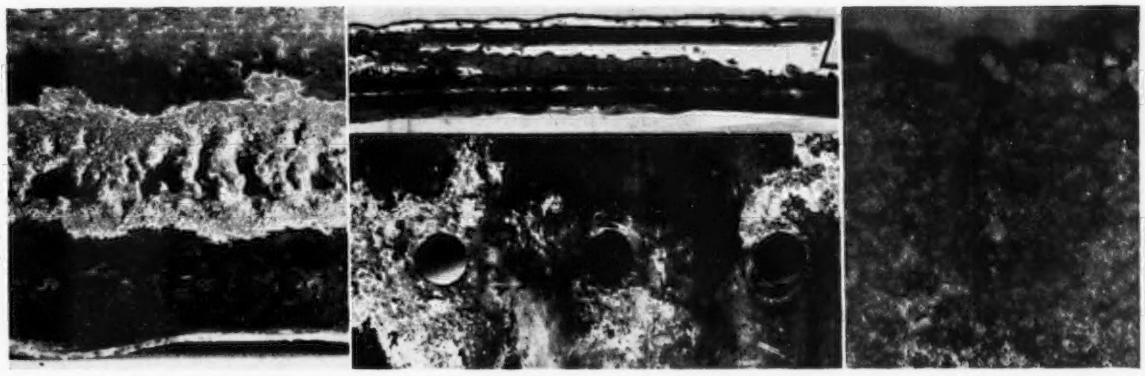

Fig. 7 *(Top center)* Flange section of bottom ring with row of holes and severe corrosion just above floor on sidewall • Fig. 8 *(Left)* Portion of bottom-ring flange shown in Fig. 7 magnified to show nature of localized attack and perforations • Fig. 9 *(Bottom center)* Corrosion around vertical joint holes of bottom ring on outside surface. This was a faying surface in a lap joint and shows that there was leakage of liquid into the joint causing corrosion • Fig. 10 *(Right)* Portion of floor plate from bin 89102. Note complete deterioration at top

ring. Perforations here are at the interface between the wet and dry corn just above the floor. The uncorroded area above the perforations was covered with dry corn while the perforated area was covered with caked, decomposed corn. A portion of this area, magnified 2 diameters, Fig. 8, shows narrow band in which severe localized attack occurred.

Corrosion also occurred by the infiltration of water in crevices formed at the faying surfaces of the joints. This is the well-known "crevice" type of corrosion which occurs when water or other liquids penetrates into loose joints.

Both alloys used for the sidewalls are very resistant to corrosion under many conditions. Both are, however, subject to corrosion involving oxygen deficiency and nonmaintenance of protective oxide films.

Floor plates from all four bins were severely corroded, being completely disintegrated in many places by exfoliation, a typical example of which is shown in Fig. 10. The compositions of all of the floor plates, Table 1, are similar but they do not correspond to any ASTM or commercial designation for wrought aluminum sheet alloy. Microexamination of the transverse sections of the sheets indicated that they were clad materials in the "as rolled" condition, containing precipitated intermetallic compounds in the grain boundaries. Fig. 11 *(upper left)* is a photomicrograph showing the general structure of the alloy and its clad layer. A pit just penetrating the clad layer is shown in Fig. 11 *(upper right)*. The clad layer will prevent corrosion of the core material until appreciable areas of the cladding are removed. When this occurs the core itself will become pitted and this material not being particularly corrosion resistant, will be penetrated rapidly. The start of penetration by pitting of the core after removal of the cladding is shown in Fig. 11 *(lower left)*.

In many places the corrosion of the floor sheets is of the intergranular type where the attack proceeds along the grain boundaries containing the precipitated compounds. In these sheets the corrosion was by exfoliation, a particularly vicious type of intergranular attack in which layers of the metal peel or flake off. A typical example of exfoliation is shown in Fig. 11 *(lower right)*.

The corn in two of the bins had been treated with fumigants, that in another had not been treated, while the condition of that in the fourth was not known. However, there was no apparent effect of the fumigants used (chloropicrin and a mixture of ethylene dibromide, ethylene dichloride, and carbon tetrachloride) upon the aluminum alloys since the corrosion of the sheets in the bins containing treated corn was no more severe than that in the bins containing untreated grain and because of the localized nature of the attack at joints.

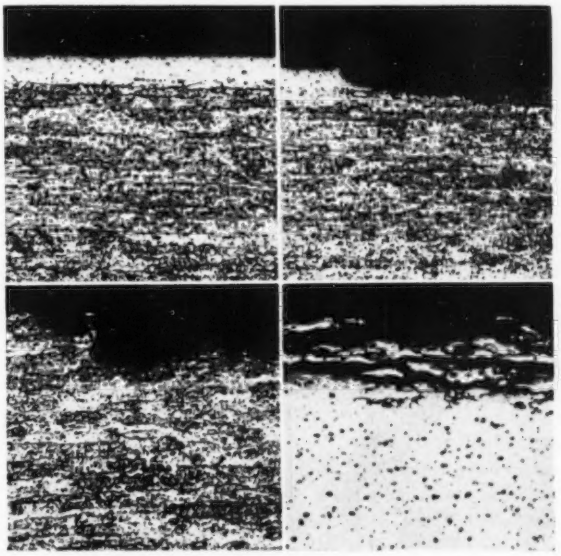

Fig. 11 Microstructure of aluminum alloy used in floor plate. *(Upper left)* General structure and clad layer. *(Upper right)* Pit penetrating clad layer. *(Lower left)* Penetration of core after complete removal of clad layer. *(Lower right)* Exfoliation corrosion (Reduced one-half from original magnification × 200.)

EFFECT OF LIQUID FUMIGANTS AND OF WET CORN ON ALUMINUM ALLOYS

In order to control insect infestation it is often necessary to treat the grain with various fumigants. The effect upon aluminum alloys of many of the compounds and mixtures which would be used for this purpose was not known. Consequently the corrosiveness of a number of these fumigants in the liquid form toward some of the aluminum alloys was investigated in the laboratory. The designation and formulas of the various fumigants are given in Table 2 and the composition of the alloys in Table 3.

Table 2. Composition of Fumigants Used and Other Exposure Environments

Fumigant Number	Composition of Fumigant, Volume Percent							
	Carbon Tetrachloride	Carbon Disulphide	Ethylene Dichloride	Bromo-trichloro-methane	Propylene Dichloride	Chloro-picrin	Ethylene Dibromide	Methyl Bromide
1	100.0							
2	80.0	20.0						
3	25.0		75.0					
4	90.0			10.0				
5	95.0			5.0				
6	25.0				75.0			
7						100.0		
8						20.0	80.0	
9						20.0		80.0
10						10.0		90.0
11	21.75		65.25			13.0		
12	72.0	18.0						10.0
13	22.5		67.5					10.0
14							80.0	20.0
15							50.0	50.0
16							20.0	80.0
17	Wet Corn - Specimens bent 90°							
18	Wet Corn - Specimens straight							

The materials with the exception of the two galvanized steels and the 9S aluminum alloy were cut into strip specimens 1 in wide x 8 in long. These three materials were cut into strips 1 in x 5 in. One strip of each material was placed in a large test tube which was then filled to 75 percent of the specimen height with a fumigant. The specimens were exposed in the liquid fumigants for various periods of time ranging from 4 to 84 days, depending upon the attack on the alloys. In the case of the very volatile fumigants the liquid levels were maintained at the 75 percent mark as long as any solution was available for the duration of the experiment. The test tubes were kept in racks in a laboratory hood where the illumination was somewhat less than that in the open room. The test period included a complete summer when there were periods of high humidity. The possible effect of light and moisture on the decomposition of organic halides was not realized until it was too late to repeat the experiment with these factors under control.

The specimens were examined frequently to determine the progress of corrosion. The results of the visual observations of the specimens after the final removals from exposure are given in Table 4.

There was no corrosion of any of the aluminum alloys by fumigants 2, 12, and 13. Alloys 3S and 4S were slightly corroded below the surface level of the liquid in fumigant 1. Fumigant 14 caused a medium attack on alloy 3S and a shallow corrosion of alloy 61S-T6, both below the liquid level. Light but not generally significant attack at or below the liquid level was also observed on most of the alloys exposed to fumigants 3 and 6. Alloy 61S-T6 was attacked somewhat more by fumigant 6 than was the other alloys. The galvanized steel specimens were only slightly corroded in all of these fumigants.

Most of the alloys were slightly attacked by fumigants 4 and 5, at or below the liquid level. Alloy 61S-T6 was somewhat more attacked than the other alloys in both fumigants, surface corrosion below the liquid level having progressed to such an extent that the specimens were removed from fumigant 4 after 30 days and from fumigant 5 after 19 days of exposure. Medium localized corrosion was also observed at the liquid level on alloys 3S, Utility Sheet, and 61S-T6 in fumigant 4 and on alloys 4S and 61S-T6 in fumigant 5. There was relatively little corrosion of the galvanized steel in fumigant 4, but the zinc coating was completely blackened in fumigant 5.

Most of the aluminum alloys were corroded by fumigants 7, 8, 9, 10, 11, 15, and 16. Alloys 3S, 4S, Utility Sheet, 61S-0, and 61S-T6 were severely corroded, most of them both above and below the liquid level. High purity aluminum and alloy 150S were the least corroded, being attacked severely only by fumigant 15. Alloy R399 was perforated by fumigants 15 and 16 and deeply pitted at the liquid level by fumigant 8. The zinc coating of the galvanized steel was blackened in all fumigants, except 10, and was completely removed in fumigants 15 and 16.

One specimen of each material was bent at an angle of 90 deg and immersed in corn so that one leg of the angle protruded above the surface. The corn was then wet nearly to the surface with water and this level was maintained by the addition of water during the life of the test. Another set of specimens with the long direction normal to the

Table 3. Chemical Composition of the Materials Used

Material			Composition, Percent by Weight									
Designation	Alloy	Thickness inch	Si	Fe	Cu	Mn	Mg	Zn	Cr	Ti	Ni	Al
KA	61S-0	0.064	0.68	0.47	0.25	0.02	0.92	0.04	0.24	0.09		Remainder
KB	61S-T6	.064	.63	.43	.31	.05	.88	.02	.16	.11		Remainder
KC	150S-H34	.064	.18	.56	.06	.03	1.71	.04	trace	.01		Remainder
KD	High Purity	.040	.10	.11	.01							Remainder
KE	2S-H14	.064	.11	.54	.14	.01	trace	.00	.00	.01		Remainder
KF	3S-H14	.064	.15	.53	.17	1.18	.02	.03	.00	.05		Remainder
KG	52S-H34	.064	.07	.20	.05	.00	2.36	.04	.21	.00		Remainder
KH	Clad 4S-H14 Core	.032	.17	.61	.14	1.17	1.06	.03	.00	.02		Remainder
	Cladding*							1.0				Remainder
KJ	9S	.027	.15	.51	.12	.16	.05	.00	.00	.01		Remainder
KA	Utility Sheet	.025	No composition available									
KB	3S-H14*	.025				1.2						Remainder
KC	R399 Embossed*	.019	.14	.70	.06	.01						Remainder
KD	R399 Plain*	.009	.14	.70	.06	.01						Remainder
KE	4S-H32*	.040				1.2	1.0					Remainder
KF	Clad 4S-H34* Core	.064				1.2	1.0					Remainder
	Cladding							1.0				Remainder
KG	R350* Core	.024	1.4(1)	1.2(1)	4.0(1)	.7(1)	.8(1)	1.0(1)			0.5(1)	Remainder
	Cladding		.3(1)	.5(1)	.1(1)	.2(1)	.1(1)	.7-1.3				Remainder
AA	4S-H14*	.051				1.2	1.0					Remainder
AB	Clad 4S-H16* Core	.072				1.2	1.0					Remainder
	Cladding							1.0				Remainder
AC	2S-H14*	.025										99 Min.
AD	3S-H14*	.040				1.2						Remainder
G1	Galvanized Steel 1	.029	Zinc 0.00070" thick equivalent to 1.67 oz/sq. ft.									
G2	Galvanized Steel 2	.029	Zinc 0.00095" thick equivalent to 2.25 oz/sq. ft.									

* Nominal chemical composition
(1) Maximum

Note - All alloy designations beginning with a K were furnished by Kaiser Aluminum & Chemical Corporation.
All alloy designations beginning with an R were furnished by Reynolds Metals Company.
All alloy designations beginning with an A were furnished by Aluminum Company of America.

TABLE 4 RESULTS OF VISUAL EVALUATIONS OF THE CORROSION OF MATERIALS IN VARIOUS FUMIGANTS AND WET CORN.

ALLOY	FUMIGANT NUMBER																WET CORN	
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17[C]	18[C]
HIGH PURITY ALUMINUM	○	○	○	○	○	○	◎	◎	◎	○	○	○	○	○	△●	○	□	○
150S	○	○	○	○	○	○	●	△◎	◎	◎	◎	○	○	○	△●	◎	□	○
52S	◎	○	○	◎	○	○	●	■●	△◎	△●	△	○	○	○	△●	○	□	□
CLAD 4S	○	○	□	○	□	○	△●	□●	▲●	△◎	△◎	○	○	○	△●	▲●	●	●
9S	○	○	□	○	□	○	●	■●	△◎	△◎	◎	○	○	○	▲●	○	◪	◎
2S	○	○	□	□	□	□◎	△●	□●	△●	△◎	◎	○	○	○	▲●	▲●	■	□
3S	◎	○	□	◪	□	□◎	▲●	▲●	▲●	▲●	▲●	○	○	●	▲●	▲●	◪	■
4S	◎	○	□	○	◪◎	◎	▲●	▲■●	▲●	▲●	▲◪●	○	○	○	▲●	▲●	◪	◎
61S-O	○	○	□	◎	◎	○	△●	■●	▲●	▲●	△■	○	○	○	△●	○	●	●
UTILITY SHEET	○	○	□	◪	◎	□	▲●	▲●	▲●	▲●	▲●	○	○	○	△●	◎	■	◪
61S-T6	○	○	◎	◪●[A]	◪●[B]	●	▲●	▲●	▲●	▲●	▲●	○	○	◎	△●	△●	■	◎
R399	○	○	□	□	□	◎	△●	■◎	△◎	◎	●	○	○	○	▲◆	▲◆	◆	●
R350	○	○	□	□◎	□	○	△◎	□●	●	△◎	△●	○	○	○	▲●	△●	◆	●
GALVANIZED STEEL 1	★	★	★	★	★	★	★	★	★	★	★	★	★	★	★	★	★	★
GALVANIZED STEEL 2	★	★	★	★	★	★	★	★	★	★	★	★	★	★	★	★	★	★
EXPOSURE IN DAYS	84	84	71	53	30	51	10	10	10	4	10	14	14	14	14	14	303	254

LEGEND:

○ - NO CORROSION
◎ - LIGHT SURFACE CORROSION BELOW LIQUID LEVEL
● - MEDIUM SURFACE CORROSION BELOW LIQUID LEVEL
● - SEVERE SURFACE CORROSION BELOW LIQUID LEVEL
◆ - PORTION OF STRIP CORRODED AWAY OR PERFORATED
□ - SHALLOW LOCALIZED CORROSION AT LIQUID LEVEL
◪ - MEDIUM LOCALIZED CORROSION AT LIQUID LEVEL
■ - DEEP LOCALIZED CORROSION AT LIQUID LEVEL
△ - MEDIUM SURFACE CORROSION ABOVE LIQUID LEVEL
▲ - SEVERE SURFACE CORROSION ABOVE LIQUID LEVEL
☆ - ZINC SPOTTED AND CORRODED AWAY ALONG EDGES
☆ - ZINC TURNED BLACK
★ - ZINC GONE COMPLETELY
★ - ZINC GONE AND STRIP RUSTED
A - EXPOSED FOR ONLY 30 DAYS
B - EXPOSED FOR ONLY 10 DAYS
C - SYMBOLS MEAN TYPE AND EXTENT OF CORROSION IN WET CORN, NO LIQUID LEVEL APPLIES

surface was also immersed in the wet corn in the same manner. These specimens were not bent.

There was some attack on all of the specimens exposed in wet corn for 303 days. These specimens were bent to simulate a flange condition, while those exposed for 254 days were not bent. While there is some difference in degree of corrosion, this is believed to be due entirely to the time element and not to bending. The corrosion of the specimens exposed to wet corn was at or below the level of the corn and severe in the case of most of the materials, alloys R399 and R350 being completely penetrated. The R399 alloys were somewhat thinner than most, being only 0.019 and 0.009 in thick. High purity aluminum and alloys 150S and 52S had shallow corrosion pits at the corn contact level and all other alloys were severely corroded. The zinc coatings were completely removed from the galvanized steels and the steels themselves were rusted.

The results of these tests indicate that the most corrosive fumigant was one containing 50 percent methyl bromide and 50 percent ethylene dibromide (15), which corroded all of the aluminum alloys, high purity aluminum, zinc and steel. It is to be noted that all fumigants containing 50 percent or more of methyl bromide corroded aluminum alloys severely. Likewise all fumigants containing any chloropicrin (7, 8, 9, 10, 11) caused severe corrosion of many of the alloys. Carbon tetrachloride alone, or combined with carbon disulphide (2), ethylene dichloride (3), bromotrichloromethane (4, 5), or propylene dichloride (6), either did not corrode the alloys at all or only very slightly. The only solution containing carbon tetrachloride which did cause considerable corrosion of some of the alloys was one containing 65 percent of ethylene dichloride and 13 percent of chloropicrin (11). In this case the chloropicrin probably was the offending agent since a similar solution containing 10 percent of methyl bromide (13) instead of chloropicrin did not corrode any of the alloys.

It must be emphasized that the fumigant tests do not reproduce the conditions which are encountered in fumigating grain in bins. All of these fumigants are volatile and when applied to grain soon disappear. Only small amounts could be absorbed by any condensed moisture resulting in much lower concentrations than those of the solutions used in these tests. Furthermore, in the laboratory tests the fumigants were exposed to light which is known to break down many organic halides, including methyl bromide and chloropicrin with the production of halogen acids which readily attack aluminum. In the absence of light, most of these fumigants are stable, and no information seems to be available as to how readily these react with aluminum, if at all. It is known, however, that methyl bromide under certain conditions, even in the dark, will react with aluminum to form aluminum trimethyl which in the presence of heat may be explosive. The wet-corn experiments likewise do not reproduce or simulate conditions as they would be found in actual grain bins because the depth of the dry-corn layer above the wet corn in the laboratory tests was not sufficient to reduce the rate of water evaporation to that which would occur under 10 or 12 ft of corn. Consequently more air had access to the wet corn in the laboratory than would be the case in a grain bin. The narrow band of localized corrosion in the side sheets of the grain bins indicated that the interface between the wet and dry corn was more or less stationary and did not rise or fall appreciably during the exposure. The wet corn would remove film more effectively in the bin and corrosion would be expected to be greater than in the laboratory.

SUMMARY

The corrosion of the side sheets in these bins was of a localized pitting nature, failure occurring by penetration of the sheets beneath caked and rotted corn at the interface between wet and dry corn. All of the corrosion was confined to areas in the vicinity of horizontal or vertical seams, where water could have entered. The alloys used are known to be corrosion resistant under many conditions and probably would have been satisfactory *(Continued on page 554)*

Effect of Soil-Aggregating Chemicals on Soils

G. S. Taylor and W. P. Martin

NUMEROUS soil investigators have shown that certain products of microbial origin are effective soil-aggregating materials. These products are principally the naturally occurring polyuronides formed during the decomposition of organic substances in soil. The effectiveness of these polyuronides is temporary, however, because they are decomposed by soil organisms and lose their soil-improving characteristics.

During the last decade, a number of synthetic chemicals have been tested for aggregating soils. Among these are potassium silicate (3)*, silicate of soda (6), and the volatile silicones (9). The effect of these compounds on the aggregation of soils and soil materials is shown in Table 1. Although these chemicals are effective in increasing aggregation in soils, they have not been used to any large extent under field conditions (5). Some of the factors delaying their use under field conditions are water-proofing effects, high alkalinity in the case of sodium silicate, and the impracticability of applying a gas of high animal toxicity in the case of the silicones. These chemicals merit more extensive field testing.

Since 1950, a number of laboratory and field experiments have been initiated in Ohio to evaluate other synthetic compounds for soil-aggregating characteristics. A more compresensive discussion of this work has been reported elsewhere (7, 8), and this report will summarize the most pertinent aspects of these studies.

All soil-aggregating chemicals used in this study are hydrophylic and readily soluble in soil moisture. They are high-molecular-weight compounds and when dissolved in water give solutions of high viscosities. These chemicals are ordinarily prepared as solids, in powder form, and take up moisture readily. If the chemicals become wetted prior to incorporation, mixing with the soil is exceedingly difficult because of the gelatinous mass that is formed. Field applications of these chemicals were generally made in the spring when the soil surface was dry. Soil moisture contents below the surface were near field capacity. The powder was spread evenly over the soil surface with a lime or fertilizer spreader and then rapidly incorporated either with a disk or a rotary tiller to a depth of 4 to 6 in. Double diskings or rotary tillage for thorough incorporation were generally practiced.

Thorough mixing of the soil-aggregating chemicals with the soil is essential for maximum aggregation. With soil moisture near field capacity, changes in structural conditions are noticeable within an hour after incorporation. When the chemicals are applied to soil near the wilting percentage, no noticeable changes in aggregation are observed until wetted by irrigation or rainfall.

TABLE 1. THE EFFECT OF SILICATES AND VOLATILE SILICONES ON SOIL AGGREGATION*

Concentration, percent by weight	Aggregation, percent soil particles >0.25 mm		
Sodium silicate	Wooster silt loam	Brookston silty clay loam	Cecil clay
0.0	12	72	67
1.2	86	69	66
3.5	96	61	90
Potassium silicate	Dunkirk silt loam	Kaolinite	Bentonite
0.0	11	12	74
0.4	55	—	—
1.0	—	14	48
3.0	—	75	26
Volatile silicones	Marshall silt loam	Ida silt loam	Clarion silt loam
0.0	42	39	51
0.2	52	48	67
0.5	65	—	68

*Data from Laws and Page (6), Dutt (3) and van Bavel (9), respectively.

Surface applications were made with the liquid and powder forms. Soil preparation prior to application consisted of plowing and disking in the usual manner for seedbed preparation. Applications were made as soon after planting as possible.

Most of the experiments were conducted on the Ohio State University farm or at outlying fields of the Ohio Agricultural Experiment Station. All experiments were of accepted statistical design with treatments applied within several replications at random. As far as possible, fertility variables were minimized by uniform applications of fertilizers.

Field work was established on Crosby and Miami silt loams, Brookston clay and silty clay loams, and on Paulding clay. Soil samples were collected periodically from the different plots for physical analyses. Disturbed samples were obtained with a spade or soil tube from many locations in each plot, and undisturbed samples were taken with a soil-core sampler. Disturbed samples were analyzed for the percentage of water-stable aggregates, and undisturbed samples

Fig. 1 Effect of 1,000 lb per acre of VAMA *(left)* and untreated *(right)* on tilth of Brookston clay loam. Treated May, 1951, and plowed one year later, May, 1952

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*Numbers in parentheses refer to the appended references.

TABLE 2. THE EFFECT OF VAMA AND HPAN ON SOME PHYSICAL PROPERTIES OF OHIO SOILS

Concentration, persent	Aggregation, percent >2 mm	Aggregation, percent >0.25 mm	Mean-weight diameter, mm	Aeration porosity, percent*	Hydraulic conductivity, in per hr
Paulding Clay (Paulding)					
0.00	10	45	0.7	18	1.6
0.05 VAMA	63	85	2.6	25	7.1
0.15 VAMA	90	94	3.8	28	8.2
Brookston Clay Loam (Hoytville)					Total porosity, percent
0.00	36.0	77.0	—	16.0	51
0.12 VAMA	67.0	92.0	—	23.0	56
0.12 HPAN	44.0	81.0	—	19.0	53
Brookston Silty Clay Loam (Columbus)					Volume weight, gm per cc
0.000	11.8	43.6	—	22.6	1.09
0.083 VAMA	49.8	72.3	—	36.0	0.99
0.083 HPAN	28.3	54.7	—	28.6	0.92

*Percent pores drained at 40 cm water tension.

were analyzed for porosity and water conductivity by procedures outlined in a previous article (8).

TESTS WITH SYNTHETIC POLYELECTROLYTES OF THE POLYVINYL TYPE

For the last two to three years synthetic polyelectrolytes of the polyvinyl type have been tested under laboratory and field conditions at practically every agricultural experiment station in this country and by the U.S. Department of Agriculture. Principal among these chemicals are hydrolyzed polyacrylonitril (HPAN) and modified vinyl acetate-maleic acid (VAMA) compounds†. These compounds in powder, flake, or liquid form have reached the market under a variety of trade names during the past year. The chemicals are usually formulated with inactive diluents to reduce hygroscopicity.

The addition of these two compounds in small amounts to Ohio soils has, without exception, increased the percentage of water-stable aggregates. As a consequence of greater aggregation, changes in soil porosity, water infiltration, permeability, and soil tilth (Fig. 1) have been obtained. These changes are illustrated by the data in Table 2 which were obtained from field samples of soils treated with VAMA and HPAN. The chemicals were incorporated with Paulding Clay and Brookston silty clay loam in May, 1951, by disking, and soil samples were taken in July and August of the same year. The Brookston clay loam was treated in May, 1952, and the soil samples taken during the summer of that year.

The addition of VAMA to Paulding clay has resulted in a pronounced shift to larger aggregate sizes which is responsible for the characteristic "crumb" appearance of treated soil. Increasing the concentrations of VAMA is reflected mainly by increasing the percentage of large aggregates. Significant increases in mean-weight diameter, aeration porosity, and hydraulic conductivity of saturated soil result from incorporation of this chemical. Similar differences have been obtained with HPAN and VAMA on Brookston soils. It can be seen from Table 2 that changes in the percentage of large pores has been most evident. Changes in total porosity and volume weights are often not significant.

Field experiments have shown that HPAN and VAMA produce similar changes in soil physical properties and differ principally in the structural level obtained per unit weight. In general, the VAMA compounds have been more effective than those of HPAN.

Stability of Aggregates. Of particular importance to the economical use of soil-aggregating chemicals is their durability in soils. Tests with radio-carbon tagged chemicals substantiate the observation of Hedrick and Mowry (4) that the polymers are fairly resistant to microbial attack. Hedrick and Mowry's conclusion was based on the persistence of chemical stabilized aggregates in a percolation apparatus for three years.

FIELD TEST INDICATE PERSISTENCE OF AGGREGATES

In a laboratory study, Brookston silty clay loam was treated with C^{14}-labelled HPAN and incubated at 27 C, while being maintained at optimum moisture contents. Provision was made for continuous collection of evolved carbon dioxide which was assayed for radioactivity. In a period of 39 days, radioactive carbon dioxide equivalent to 0.97 percent of the added conditioner was produced as a result of microbiological activity; 13 percent of this was produced in the first 24 hr of the incubation‡.

Field tests also indicate persistence of the aggregates produced by these two chemicals. Results are shown in Table 3 for Miami subsoil treated over two years ago. At the higher rates of application, aggregation remained significantly higher in the treated than in the untreated soils for two years. Although slow deterioration of aggregates is indicated with time, one can not separate the effects of microbial decomposition and mechanical breakdown of the aggregates as a result of plowing and cultivation in this experiment. In other field tests where VAMA at the rate of 0.05 percent was added annually for three years to Brookston clay loam in a plow layer application, it was noted that appreciable breakdown of aggregates occurred each year from the levels obtained at the time of application. Aggregation at the end of the third season, however, was substantially above that at the beginning of the experiment, i.e., 46 percent in 1950 and 65 percent in October, 1952; controls, 30 percent and 32 percent for the same dates, respectively.

Application Rates. The amount of soil-aggregating chemical needed to effect satisfactory structural change is of much interest because these compounds are expensive. While

†Appreciation is expressed to Monsanto Chemical Co. for supplying these materials.

Fig. 2 Liquid application of 30 lb HPAN per acre over crop row. Notice slaking and crusting of soil in untreated area

‡Data supplied by J. L. Mortensen.

TABLE 3. CHANGES IN THE AGGREGATION OF TREATED AND UNTREATED MIAMI SUBSOIL (SILTY CLAY) WITH TIME*

Treatment	1950 (avg.)		Aggregation, percent soil particles April, 1951		Nov., 1951		April, 1952	
	>2.0 mm	>0.25 mm	>2.0 mm	>0.25 mm	>2.0 mm	>0.25 mm	>2.0 mm	>0.25 mm
Untreated	8	33	7	31	5	28	5	33
0.05 percent VAMA	22	51	22	51	14	41	7	32
0.05 percent HPAN	19	49	12	44	10	35	8	35

*Treated in May, 1950, incorporated by disking or rototilling, plowed and disked between crops: corn, 1950; soybeans, 1951; oats, 1952.

obviously the resultant of many factors, the smallest quantity found to be effective in field tests on Miami subsoil was 0.01 percent which increased aggregation (soil particles >0.25 mm) from 31 to 40 percent. Water-stable aggregates in the size range above 2 mm was increased from 7 to 13 percent. Significant corn yield increases were obtained on this same soil treated with 0.02 percent VAMA (8). Larger quantities of the soil-aggregating chemicals increase the shift to larger particle sizes as shown in Table 2. To be assured of effective structural change, it is likely that 0.05 percent concentration, or about 500 lb per acre, will have to be used if it is incorporated with the top 3-4 in of soil.

For maximum benefits from synthetic soil-aggregating chemicals, it has been noted that they must be thoroughly mixed with the soil. For best results the soil should contain enough moisture for good workability but the surface on which applied should be dry. If too wet, "gumming up" occurs and good mixing is difficult. If the soil is dry at the time of application and for a long period thereafter, maximum aggregation frequently does not occur. Soil-aggregating chemicals applied as a liquid have been principally effective on prepared seedbeds for the prevention of crusting and control of erosion.

Factors Influencing Effectiveness of Chemicals. Two factors which have been noted to influence the effectiveness of soil-aggregating chemicals are soil texture and clay-mineral makeup. In general, greater aggregation has been obtained in the fine-textured soils than in the coarse-texture ones (8). The VAMA chemicals are more effective on illite and kaolinite than on calcium bentonite and also "stabilizes" fine quartz particles (1). An anomaly – good aggregation on soils containing appreciable quantities of bentonitic or montmorillonitic clays have been obtained. Other factors such as organic matter content, salt content, and soil reaction probably influence the effect of these chemicals on soil aggregation.

Preliminary tests with C^{14}-labelled polymers§, indicate that they bond to the soil particles very quickly in solution and do not move appreciably thereafter. When dry-mixed and then leached, appreciable movement occurs, probably during the solubilizing process. Radio-carbon, however, was not detected in the leachate from a 16-in soil column through which was passed 39 in of water.

§These studies being conducted by J. L. Mortensen, research fellow.

TABLE 4. THE EFFECT OF CMC-120 HIGH* ON AGGREGATION OF MIAMI SILT LOAM IN TOP ½-IN SOIL

Treatment†	Aggregation, percent soil particles >0.25 mm
Untreated	34
0.1 percent incorporated to 3 in	57
0.1 percent applied to surface as liquid†	49
0.1 percent applied to surface as powder	51
0.1 percent incorporated to 3 in plus 0.1 percent applied to surface as liquid	72
0.1 percent incorporated to 3 in plus 0.1 percent applied to surface as powder	73

*1.2 positions of three available hydroxyls on the molecule substituted with carboxymethyl groups. High molecule weights and thus high viscosity.
†Surface applications calculated on basis of ½ in of soil.

TESTS WITH CARBOXYMETHYLCELLULOSE

Another class of synthetic chemicals being tested at various agricultural experiment stations for aggregating soils is carboxymethylcellulose (CMC). Naturally occurring cellulose compounds in soil are susceptible to microbial decomposition, although the partial substitution with carboxymethyl groups of available positions on certain cellulose gums appears to increase resistance to decomposition. Laboratory studies at Ohio State University have shown that cellulose compounds containing this type of substitution are effective in aggregating clay materials and soils when properly applied (2). Limited field tests with some of these compounds‖ are positive, although these trials have not been conducted over a sufficiently long period to give complete information on aggregate stability. The data given in Table 4 show the effect of CMC (with 1.2 positions on the molecule substituted with carboxymethyl groups) on the aggregation of Miami silt loam. This experiment was initiated on the horticulture farm, Ohio State University, in September, 1952, to test several soil-aggregating chemicals for their effect on soil aggregation. For those treatments in which the chemical was mixed with the soil, the powder form was applied on the surface and incorporated by disking three times. All surface treatments were applied on the plots after seeding of row crops without subsequent incorporation with the soil. It can be seen from these data that both powder and liquid forms are effective in aggregating soil.

Soil samples were taken for aggregate analysis at the end of one and two months after treatment. A wet-sieve aggregate analyses showed no deterioration of aggregation by the last date. Subsequent analyses from this experiment and from others being initiated will provide more accurate information on these chemicals.

RUNOFF AND EROSION

Because of high infiltration rates generally found in soils treated with soil-aggregating chemicals, some runoff and erosion plots were initiated at Wooster in 1951 and 1952. The tests in 1951 indicated that runoff and erosion were significantly reduced on treated soil (7). In the 1952 experiment, wheat about six inches high was turned under by plowing. The soil-aggregating chemicals were incorporated by disking to the depths indicated and corn planted in the usual manner. The average slope on these plots was 10 percent. The results are shown in Table 5.

Runoff was significantly decreased by all rates of soil-aggregating chemicals. Increasing the rates of VAMA resulted in decreasing runoff although, it is doubtful if run-

‖Appreciation is expressed to Hercules Powder Co. for supplying these materials.

TABLE 5. THE EFFECT OF VAMA AND HPAN ON RUNOFF AND EROSION ON WOOSTER SILT LOAM (Wooster, 1952)*

Soil treatment chemical and rate per acre, lb	depth incorporated, in	Runoff†, in	Erosion, tons per acre
0	—	4.12	7.1
VAMA, 200	1	1.60	5.8
VAMA, 800	4	1.04	4.6
VAMA, 1600	4	0.95	1.0
HPAN, 800	4	0.79	0.5

*Data supplied by H. L. Borst, associate agronomist, USDA, and Ohio Agricultural Experiment Station.

†For the period June-September. Total rainfall during this period was 7.17 in.

off at the 800-lb rate differs significantly from the other two rates of VAMA. Apparently infiltration rates in the top one inch of soil was the critical factor in this experiment. The application of HPAN was more effective than a similar rate of VAMA in reducing runoff. No satisfactory explanation can be found for this result since HPAN is generally less effective than VAMA in aggregating soil.

Erosion was significantly reduced only at the 800 and 1600-lb rates. Erosion at the 1600-lb rate of VAMA was significantly lower than for other rates of this chemical. As with runoff, the 800-lb rate of HPAN was more effective in reducing erosion than VAMA.

The effect of HPAN on runoff and erosion from Muskingum silt loam watersheds is shown in Table 6. In this investigation, sod land was prepared on one watershed by normal plowing and on the other by subsurface (mulch) tillage. The HPAN was applied to a one-acre watershed after plowing and double disked twice to 4 to 5 in. Corn was planted in the usual manner, and runoff and erosion measured from May through September.

One can see from these results that both HPAN and the mulch were effective in controlling runoff and erosion. Infiltration rates on the mulch and HPAN-treated soils were high. The increase in corn yield on watershed numbers 188 and 199 was correlated with higher soil moisture contents.

EFFECT ON PLANT GROWTH AND YIELD

Since the effect of soil-aggregating chemicals on crop yield has been reported in detail elsewhere (7, 8) these results will only be summarized here.

Tomatoes. The importance of improving soil physical properties on satisfactory crop production was strikingly demonstrated by results obtained on Paulding clay (Table 2) the second growing season after treatment with VAMA. On two occasions during the spring of 1952, surface water was observed on the untreated soil. Internal drainage was probably responsible for differences found in the survival of tomatoes on these plots. The relative stand at maturity for the 0, 0.05, and 0.15 percent concentrations of VAMA was 60, 70, 100, and the relative yield was 41, 65, 100, respectively (7). It was also observed that tomatoes matured earlier on the treated soil. Similar observations have been noted with corn on Brookston clay loam treated with VAMA (7).

TABLE 6. THE EFFECT OF HPAN ON RUNOFF, EROSION, AND CORN YIELD OF MUSKINGUM SILT LOAM (Coshocton, 1952)*

Watershed number	Soil treatment	Runoff†, in	Erosion tons per acre	Corn yield, bu per acre
121	Plowing, contour rows	1.12	1.60	54.0
188	Subsurface (mulch) tillage, contour rows	0.05	0.03	81.0
199	Plowing, 1,000 lb HPAN per acre, contour rows	0.01	0.01	83.0

*Data supplied by L. L. Harrold, project supervisor, Soil Conservation Service Research, Coshocton.

†For the period May-September. Total rainfall during this period was 14.33 in.

Potatoes, Carrots, Lettuce, and Sweet Corn. In 1951, Brookston clay loam was treated with three rates of VAMA and subsequent crop yields were taken in 1951 and 1952 (7, 8). These rates were 0 (check), 2000 and 4000 lb per acre. Soil aggregation was significantly higher in the treated than in the check plots during both years, although this difference in aggregation decreased with time. Potatoes were grown in 1951 but showed no differences in yield as a result of treatment. Potatoes were followed by carrots which yielded 11 and 21 percent higher than the check for the 2000 and 4000-lb rates, respectively.

In 1952, head lettuce was transplanted in these plots. As with potatoes, no yield increases were found as a result of soil treatment. However, sweet corn which followed head lettuce produced 20 percent more in the treated than in the untreated soil. There were no differences in yield between the two rates of VAMA.

Oats and Alfalfa. In another experiment, Crosby silt loam on the agronomy farm was treated with VAMA in three ways: (*a*) 0.1 percent mixed with the top 4 to 6 in with a "culti-mulcher," equivalent to disk mixing, (*b*) 0.1 percent (for ½-in depth) placed on the surface and incorporated lightly with a rake, and (*c*) drilled with fertilizer at rates of 200 lb per acre. For the sake of uniformity, all plots were culti-mulched before being given other treatments. Rates of application in all treatments were estimated to be the same for the soil brought into contact with the chemical; however, rates per acre varied markedly. This experiment was designed to test the effect of VAMA treatment on the establishment and growth of alfalfa and also of the oats companion crop.

Soil aggregation was markedly increased by 0.1 percent VAMA disk-mixed with the soil, and Clinton oats yielded 40 percent higher in these soils. Plants averaged almost a foot taller in the treated plots. This was one of the most spectacular crop responses to soil-aggregating chemicals noted among these experiments.

Aggregation was not affected significantly by the surface application and drilled treatments. Further investigations have shown that maximum benefits occur if the surface applications are not mixed with the soil. With the rhizophere largely untreated, oats in the surface-treated soils did not yield significantly higher than the controls. A marked reduction in yield occurred when the seed was drilled with VAMA. This reduction was largely the result of decrease in stand. In large concentrations, the chemical becomes gelatinous. It also has high alkalinity. It is postulated that under these conditions germination is reduced.

Because of a tendency for the VAMA-treated soils to dry out on the surface more quickly following precipitation, it was feared that the alfalfa stand might be reduced. When the number of plants in several randomly placed square-yard areas per plot were counted in September, 1951, however, no significant differences were obtained. Alfalfa yield taken in 1952 showed that the different treatments did not significantly affect its growth.

IMPROVING GERMINATION BY AMELIORATING SOIL CRUSTING

The cost of soil-aggregating chemicals is high and this combined with the extra labor involved in their application will seriously reduce their usefulness in general agriculture for improvement of the structural condition in the entire plow layer of soil. Uses that require minimum amounts of material will thus be of most immediate interest. One way that has been found to decrease rate of application is to treat only the top one-half inch of soil. Crusting has been ameliorated with powder applications dusted onto the surface of a previously prepared seedbed and with liquid preparation sprinkled or sprayed on the soil surface (Fig. 2). One-fifth pound of active VAMA, HPAN, and CMC 120 High per hundred square feet (0.05 percent rate or less than 100 lb per acre) has prevented serious crusting and facilitated the emergence of bean seedlings and other vegetable crops on Brookston and Miami soils. Tests have also shown VAMA and HPAN effectively prevent erosion on sloping lawn surfaces and road banks. For vegetable row crops, spray treatment of a band of soil above the row immediately after planting has reduced the amount of chemical needed still further to about 30 lb per acre or less depending upon row width. It is important to emphasize that the above results were obtained where the chemicals were applied to a seedbed with a minimum of disturbance during application and no attempt made subsequently to incorporate them by raking. This latter procedure has, in some instances, induced crust formation which has been partially consolidated by the soil-aggregating chemical after wetting.

It should be noted that because of a tendency of well-aggregated soils to dry faster on the soil surface that the soil-aggregating chemicals cannot completely take the place of an organic mulch even though serious erosion may be prevented. In both spring and fall plantings, the establishment of tender grass seedlings was facilitated by a light straw mulch. Soil receiving surface applications of HPAN has not dried faster than untreated soil.

SUMMARY

The effect of several synthetic soil-aggregating chemicals on the physical properties of fine-textured Miami, Crosby, Brookston, and Paulding soils has been studied. Application rates varying from 0.05 to 0.15 percent have been applied in both powder and liquid forms. Pronounced changes in soil aggregation and such related characteristics as pore-size distribution, water infiltration, and hydraulic conductivity have been obtained. Large aggregates ($>$ 2 mm in diameter) were commonly produced and these aggregates proved to be water-stable and rather resistant to microbial decomposition.

The effect of soil-aggregating chemicals on the growth of many crops was tested in statistically controlled field experiments. Not all crops responded to treatment, although appreciable increases in the yield of field tomatoes, corn, oats, and carrots have been obtained. Field tests have shown these chemicals to be effective in preventing soil crusting and reducing runoff and erosion.

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Corrosion of Grain Bins

(Continued from page 549)

for storage-bin construction where the moisture content of the grain was normal. Caulking or sealing of the seams to make them watertight is recommended to prevent the entrance of water and subsequent corrosion of the sheets by localized pitting, and it is believed that if corn of normal dryness is stored and water subsequently prevented from entering no serious corrosion will occur.

The corrosion of the floor sheets was largely by exfoliation. The material used for these sheets is a copper-bearing aluminum alloy which is not particularly corrosion resistant in the hot-rolled condition. A protective cladding prevented corrosion for some time, but when this thin cladding was penetrated, the sheets corroded at a rapid rate. The bottom ring and floor sheets of all aluminum bins should be coated on both surfaces with a moisture-resisting paint, similar to the practice now obtaining in some installations.

There is no evidence that fumigants were a factor in causing or promoting corrosion of the grain bins. The laboratory tests in which no corrosion was observed, as with the fumigants containing carbon disulphide, show that those fumigants could have no effect on any aluminum alloy that might be used. The tests in which corrosion was observed, however, should not be interpreted as indicating that substances such as chloropicrin should be banned as fumigants because the laboratory tests were made in light which is known to break down such materials with the formation of acid. Only further experimental work can give a definite answer.

The most resistant of the alloys to the liquid fumigants tested was high purity aluminum, 150S, and 52S. The least resistant were 61S-T6 and R350, with the other alloys intermediate. In properly sealed or caulked bins most of the aluminum alloys tested could be used for grain storage. It is important, however, that the interior of the bins should be dry with no chance for the leakage of rain water in the sides or infiltration of the floor by ground water.

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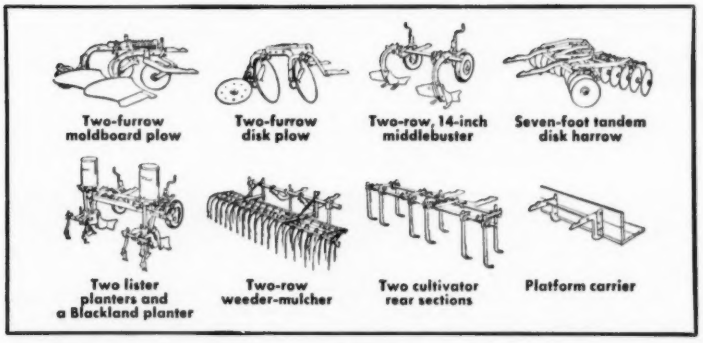

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NEWS SECTION

SAE Tractor Meeting

THE national tractor meeting sponsored each year by the Society of Automotive Engineers will be held as usual at the Hotel :hroeder in Milwaukee. The dates of the 1953 meeting are Septem-:r 14 to 17. Information concerning the program for the meeting id not been received up to the time of going to press.

Pacific Northwest Section Meeting

SEPTEMBER 9 to 12 are the dates for the annual meeting of the Pacific Northwest Section, to be held at the University of British Columbia, Vancouver, B.C. The dates were set at a meeting of the Section executive committee on June 12, following investigation indicating that most suitable accommodations would be available at that time in September.

Members attending the executive committee meeting included T. K. Dimmitt, Sectional chairman, R. S. Tait, Section secretary, M. C. Ahrens, L. W. Bonnicksen, J. R. Caverhill, T. L. Coulthard, H. D. Currey, M. C. Jensen, D. R. Long, F. G. Maloney, A. G Mayer, M. H. J. Miller, L. J. Smith, and E. L. Towne.

A full program was tentatively planned for September 10 and 11. General sessions were indicated for 8:30 a.m. to 4:00 p.m., September 10, followed by a picnic lunch at Mount Seymour, and concurrent evening programs. A featured speaker and student papers were planned for the morning and early afternoon of September 11, to be followed by concurrent division programs and Section dinner.

Extension Exhibit Winners

EXHIBITS sponsored by the ASAE Committee on Extension were a main center of attraction during the annual meeting of the Society at Pittsburgh in June. The official list of blue ribbon award winning entries in the various classifications is as follows:

Motion picture: (1) Industrial class—"Better Fencing," Koppers Company, Inc., and "Fire Cisterns for the Farm," Portland Cement Association. (2) Public agency class—"Hands Off," Iowa State College.

Slides: "Electrical Safety and Maintenance on the Farm," Utilization Committee Farm Section, Edison Electric Institute; "Water the Hidden Menace to Homes," National Paint, Varnish and Lacquer Association; "Infrared Lamps for Brooding and Other Uses," Ohio State University.

Publications: (1) Industrial class — "Sprayer and Duster Model," National Sprayer and Duster Association; "Electrical Demonstrations You Can Perform," Westinghouse Electric Corp.; "Fences That Pay," United States Steel Company; "Haying Hints," New Holland Machine Company. (2) Public agency—"Maintaining the Farm Wiring and Lighting System," Southern Association of Agricultural Engineering and Vocational Agriculture; "Space Design for Household Storage," University of Illinois; "Give Your Corn Air," Virginia Polytechnic Institute; "Labor-Saving Ideas on the Farm," Oklahoma A. & M. College.

ASAE Meetings Calendar

August 31—September 2 — NORTH ATLANTIC SECTION, Long Island Agricultural and Technical Institute, Farmingdale, L. I., N. Y.

September 9-12—PACIFIC NORTHWEST SECTION, University of British Columbia, Vancouver.

September 25 and 26—ALABAMA SECTION, Gulf Shores.

December 7-9—WINTER MEETING, Edgewater Beach Hotel, Chicago, Ill.

April 2 and 3—Colorado A. and M. College, Fort Collins.

June 20-23—47th ANNUAL MEETING, University of Minnesota, Minneapolis.

NOTE: Information on the above meetings, including copies of programs, etc., will be sent on request to ASAE, St. Joseph, Michigan

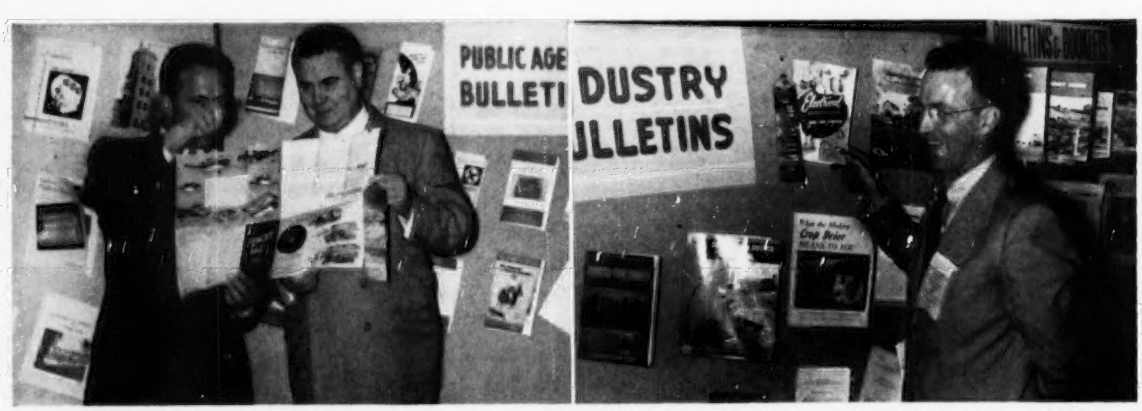
Demonstration Models: Platform Baled Hay Drier Model, North Carolina State College; Insulated Pump House Model, University of Nebraska; Pole Stable Model, Cornell University.

This display sponsored by the Committee on Extension was supplemented this year by industrial exhibits provided by local organizations cooperating in sponsoring the Pittsburgh meeting. They include the Aluminum Company of America, American Radiator and Standard Sanitary Corp., A. M. Byers Company, Copperweld Steel Company, Crucible Steel Company of America, Dravo Corporation, Duquesne Light Company, Gulf Oil Corporation, Koppers Company, C. A. McDade Company, McDowell Manufacturing Company, Mine Safety Appliances Company, National Electric Products Company, Oliver Iron & Steel Company, Pennsylvania Power Company, Pittsburgh Forgings Company, Pittsburgh Plate Glass Company, Pittsburgh Screw & Bolt Corporation, Pittsburgh Steel Company, Robinson Ventilating Company, Townsend Company, United States Steel Corporation, West Penn Power Company, and Westinghouse Electric Corporation.

Members of the ASAE Committee on Extension are K. H. Hinchcliff (general chairman), I. D. Mayer (vice-chairman), J. L. McKitrick, J. L. Calhoun, D. L. Maxwell, B. P. Hess, E. A. Olson, G. O. Schwab, C. E. Worlan, I. P. Blauser, C. E. Hervey, J. M. Ferguson, R. T. Scott, F. W. Andrew, C. N. Hinkle, C. V. Phagan, J. P. Schaenzer, V. S. Peterson, H. E. Stover, W. S. Allen.

New American Standard for Small Solid Rivets

A NEW standard for small solid rivets was recently approved by the American Standards Association, the sponsors of which were the Society of Automotive Engineers and the American Society of Mechanical Engineers. Printed copies of the standard may be obtained from the latter society, 29 West 39th St., New York 18, N. Y., at a price of $1.00 per copy. *(News continued on page 558)*



(Left) C. E. Hervey (left), chairman of Subcommittee on Bulletins, and F. J. Reynolds (right) of United States Steel Co., whose bulletin "Fences That Pay" won an industrial class award in the exhibits competition sponsored by the ASAE Committee on Extension at the Society's 1953 annual meeting in Pittsburgh • *(Right)* R. T. Scott of Westinghouse Electric Corp. holding an award-winning bulletin of his company in the industrial class in the ASAE extension exhibit

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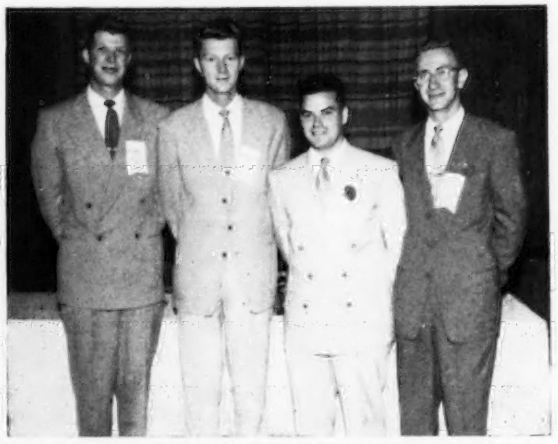
Representatives of the Pennsylvania Student Branch of ASAE and the 1953 Farm Equipment Institute trophy which was awarded to the Branch at the ASAE annual meeting at Pittsburgh in June. Left to right, they are Ernest Gingrich, Morris E. Schroeder (president), Max Demiawovich, and Gerald S. Birth. (Photo by B. P. Hess, Westinghouse)



The newly elected officers of the 1953-54 National Council of ASAE Student Branches. Left to right, Don Meyer, president (University of Missouri), Charles Overman, vice-president (North Carolina State College), Richard Russell, vice-president (University of Vermont), and Deane Miller, secretary (Iowa State College). (Photo by B. P. Hess, Westinghouse)

Two FEI Awards Presented

THE Pennsylvania and Ontario Student Branches of ASAE were winners of Farm Equipment Institute trophy cup awards presented during the ASAE annual meeting at Pittsburgh in June, for conspicious organization activity during the past school year.

This was the first year in which two awards were made, based on competition in separate "heavyweight" and "lightweight" divisions according to membership strength.

It was also the first time that the presentation was made at a complimentary dinner for student members and faculty advisors, sponsored by the Farm Equipment Institute. The dinner was held on Tuesday evening, June 16, and featured addresses by Ivan D. Wood, president of ASAE, and A. E. W. Johnson, vice-president and director of engineering, International Harvester Co. It also featured a color movie, "Development of a New Tractor and Implement Hitch," presented by Edwin W. Tanquary, president-elect of ASAE. F. P. Hanson, chairman of the Research Committee of FEI, presided.

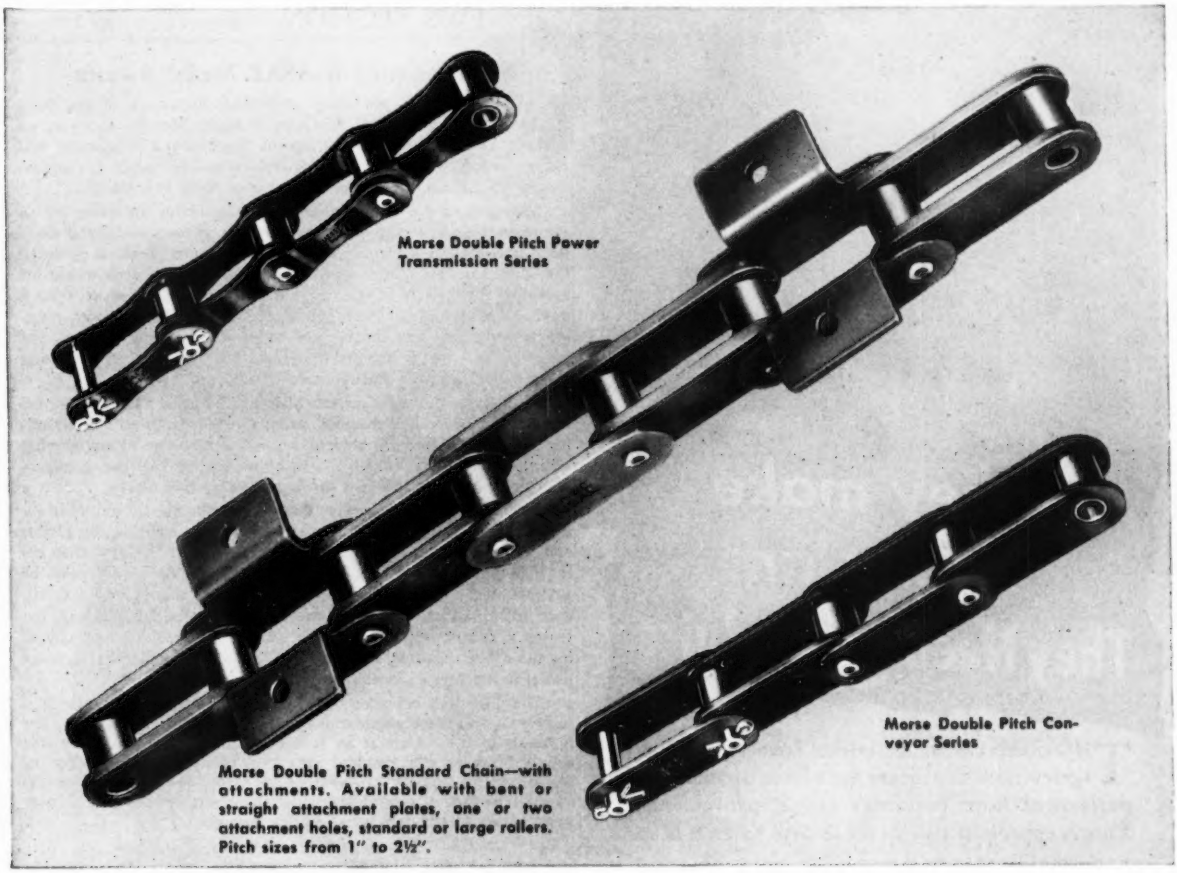
Announcement and presentation of the awards was by C. K. Beeman, chairman of the Committee on FEI Trophies. Other members of the Committee were M. E. Weakly and R. L. Cade.

The Committee on Student Branches which has an active advisory role in administration of the competition and other student branch matters, was represented by C. L. Zink, chairman. Its members include L. H. Ford, R. L. Green, F. W. Peikert, P. A. Whisler, R. W. Whitaker, and G. E. Fairbanks.

Top branches in the scoring of the competition, in each division, were as follows: Group A—Pennsylvania, Ohio, Illinois, Indiana, and Iowa; group B—Ontario, Minnesota, Montana, South Dakota, and Washington. *(News continued on page 560)*

In this picture Karl H. Norris (Member ASAE), agricultural engineer, Division of Farm Electrification, U.S. Department of Agriculture, is shown demonstrating to President Eisenhower the shell-color egg-grading machine which separates eggs into six groups according to shell color. The machine was developed by USDA agricultural engineers in cooperation with the poultry section of the Bureau of Animal Industry as part of a joint project on the development of automatic egg-grading equipment. At the extreme left is Secretary of Agriculture Ezra Taft Benson and to the left and in from him is the President. (Photo courtesy of USDA)

(Left) This sanitary pump installation model of the University of Nebraska won an award in the ASAE Committee on Extension exhibits competition at the Society's 1953 annual meeting. L. W. Huribut (right) receives the blue ribbon for E. A. Olson who entered the exhibit. F. W. Andrew (left), chairman of the Subcommittee on Models, made the award • *(Right)* G. E. Henderson, Southern Association of Agricultural Engineering and Vocational Agriculture, holds the bulletin "Maintaining the Farm Wiring and Lighting System" which won the blue ribbon award in the public agency class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These tough, precision-built chains cut problems raised by gradual pitch elongation to a new low. They're steel—cold-rolled, fine-grain alloy steel, heat treated and shot-peened for maximum endurance and strength.

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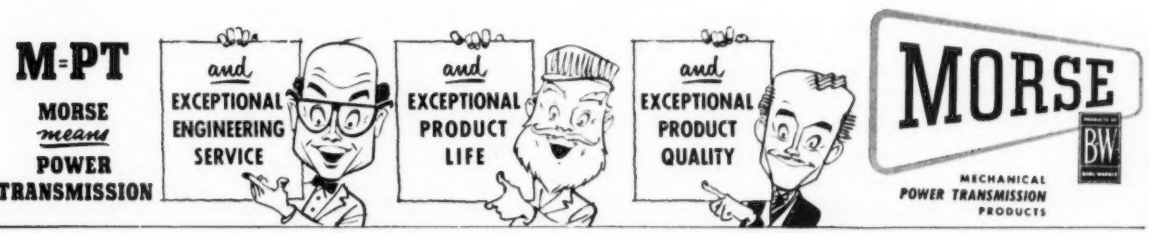
Bushings are case-hardened and curled for maximum wear. Smooth inner bearing surfaces and true roundness help eliminate pin scoring, increase joint life, reduce elongation. Link plates are treated to obtain maximum strength and endurance necessary in highly stressed tension parts.

Let us give you details on Morse Double Pitch for your special needs. Write Morse Chain Company, Dept. 506, 7601 Central Ave., Detroit 10, Michigan.



As they make their plans . . . They Need Your Advice

THOUSANDS of American farmers look to agricultural engineers for advice on building permanent farm buildings and improvements. This is especially true in these days when it is so important to save feed and labor and to increase production.

You will give farmers sound advice if you recommend concrete construction for farm structures and improvements. There are hundreds of places where concrete is the logical construction material, but there's no place where it is more needed than on the farm. Concrete is durable, sanitary, decay-proof and ratproof. Its firesafety makes it the logical choice for farm use. In addition, its lifetime economy—moderate first cost, low upkeep and long years of service—make concrete a wise investment.

You can get free illustrated literature that will be helpful in designing and building economical, firesafe and long-lasting concrete buildings and improvements such as poultry houses, fruit storage plants, dairy barns, hog houses, machine sheds, milk houses, and many other profit-making farm structures. Distributed only in the United States and Canada.

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A national organization to improve and extend the uses of portland cement and concrete . . . through scientific research and engineering field work

NEWS SECTION *(Continued from page 558)*

Nominations for ASAE Medal Awards

IN ACCORD with the rules governing the award of the John Deere and Cyrus Hall McCormick Gold Medals, the Jury of Awards of the American Society of Agricultural Engineers will receive from members of the Society, up to November 1, nomination of candidates for the 1954 awards of these two medals.

Members of the Society nominating candidates for either award are requested to keep in mind the purposes of each medal and make their nominations accordingly. The John Deere Medal is awarded for "distinguished achievement in the application of science and art to the soil," which citation is interpreted to cover more than a mechanistic concept of engineering, and to include chemistry, physics, biology, and any other science and art involving the soil, the "application" being acceptable to evaluation by the engineering criteria of practicality and economic advantage.

The Cyrus Hall McCormick Medal is awarded "for exceptional and meritorious engineering achievement in agriculture." Selections for the award may be in recognition of a single item of engineering achievement, but is more likely to be on the basis of the aggregate of weighted accomplishment through a continuing career.

The Jury of Awards desires that members of the Society consider it their duty and obligation to give serious thought to the matter and nominate for either or each of these awards the men they believe to be most worthy of the honor. Each nomination must be accompanied by a statement of the reason for nominating a candidate and qualifications of the nominee, including his training, experience, contributions to the field of agriculture, a bibliography of his published writings, and any further information which might be useful to the Jury in its deliberations.

The Jury will consider nominations received on or before November 1, and these nominations should be addressed directly to the Secretary of the Society at St. Joseph, Michigan. The Secretary will supply on request a standard set of instructions for preparing information in support of nominees for the Society's gold medal awards; in fact, it is important that these instructions be followed in preparing material on behalf of any nominee.

Mechanization Emphasized in OES Report

PROGRESS in farm mechanization aided by research at the state agricultural experiment stations is emphasized in a report to Congress on the work of the stations for the fiscal year 1952. The report was prepared by R. W. Trullinger, chief of the USDA Office of Experiment Stations, with the collaboration of the technical staff. Copies of the report were recently given limited circulation to the press.

In indicating the state of progress of mechanization and resulting advantages to farmers and the whole country, the report reads, in part as follows:

"In this 1952 report the Office of Experiment Stations has singled out for special emphasis, typical representative examples of the rapid advances made in the mechanization of crop production through research at the state agricultural experiment stations. Nowhere can the practical, operating farmer find more tangible proof that research pays off than in the substitution of mechanical power for human labor and work animals. Since the early days of American history our farmers have sought short cuts to overcome the weariness and drudgery of waste motion. Ever since Thomas Jefferson applied the principles of mathematical science to improve plow moldboards and thereby upset the traditional plowing practice of many centuries, the farmers of America have been interested in the development of mechanical improvements in their tools of production.

"The degree of farm mechanization in the United States today cannot be measured by merely counting the number of tractors and other machines used on these farms. The true test of the impact of mechanization on farm operations in this country is the effectiveness with which machinery is used and the economy of power obtained in its operation. The greatest concern of agricultural engineering research, therefore, is to find new ways of utilizing farm power effectively and economically.

"As a result of the investigations in the field of agricultural engineering research carried on from time to time in the state agricultural experiment stations, back-breaking labor on farms is rapidly passing and is being replaced by mechanical devices and procedures that not only save time and labor but also improve the quality and increase the yields of food and fiber products."

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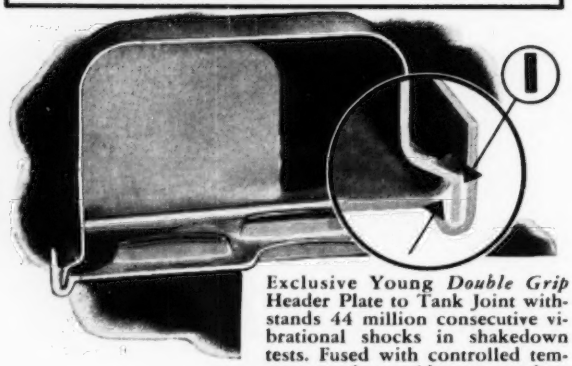
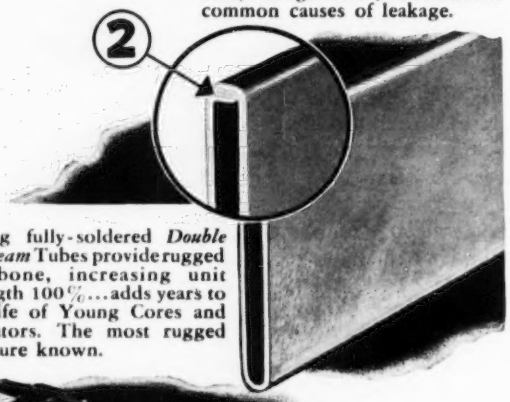


Exclusive Young *Double Grip* Header Plate to Tank Joint withstands 44 million consecutive vibrational shocks in shakedown tests. Fused with controlled temperature hot solder to produce sure, stronger bond, and eliminate common causes of leakage.



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NEWS OF ASAE MEMBERS

THOMAS W. BROCK has resigned as assistant to the supervisor of agricultural advertising, Caterpillar Tractor Co., to accept appointment as an associate account executive with the advertising agency, Fuller & Smith & Ross, Inc., Cleveland.

• • •

ERNEST R. CUNNINGHAM, JR., has resigned as a consulting engineer with the Lavers Engineering Co., to accept a position in the engineering department of the Frank G. Hough Co., Libertyville, Ill.

• • •

HAROLD E. DEBUHR, a 1951 agricultural engineering graduate and until recently on duty with the U.S. Air Force, is now employed as a student engineer at the John Deere Ottumwa Works of Deere and Co., Ottumwa, Iowa.

• • •

CLARENCE R. FAHNESTOCK recently severed his connection with the Doane Agricultural Service to accept appointment to the position of agricultural engineer at the Matanuska Experiment Station at Palmer, Alaska.

• • •

R. BRUCE HOPKINS, who has been serving as assistant agricultural engineer at the University of Maine, recently accepted appointment as graduate assistant in the agricultural engineering department of Michigan State College.

• • •

KENNETH A. KOCH has been named extension agricultural engineer, Louisiana Agricultural Extension Service, for work in irrigation and rural electrification. He was formerly agricultural engineer with the Soil Conservation Service at Columbia, S. C.

• • •

LAWRENCE W. LARSON, formerly a member of the agricultural engineering staff of the University of Hawaii, recently accepted appointment as assistant agricultural engineer in the agricultural engineering department at Cornell University, Ithaca, N. Y. His new work will include the design and development of feed-handling equipment.

• • •

DALTON G. MILLER, formerly materials engineer, Bureau of Public Roads, U.S. Department of Commerce, but now retired, was honored at the 56th annual meeting of the American Society for Testing Materials held at Atlantic City in June, when he was given the ASTM Award of Merit for important contributions to the work of that organization. The award was for notable service particularly in Committee C-1 on cement where he has contributed important papers and reports, as well as rendered service in other fields of ASTM work. Mr. Miller was awarded the John Deere Gold Medal by ASAE in 1948.

• • •

VERNON N. PAULSON, who has been serving as assistant western sales manager of the Russell, Burdsall & Ward Bolt and Nut Co., at the company's Chicago office, was recently promoted to manager of western industrial sales, and his office is being moved from Chicago to the company's plant at Rock Falls, Ill.

• • •

PAUL E. SCHLEUSENER joined the agricultural engineering staff at the University of Nebraska August 1. He was previously engaged in graduate work at Michigan State College.

• • •

MALCOLM E. SERGEANT, farm department representative, Central Vermont Public Service Corp., in his capacity as chairman of the Vermont Electric Utilization Council reports that the Council is sponsoring a safety program in which 20,000 safety stickers bearing the words "15 Amps Are Ample," are being distributed among more than 500 4-H young people in the state and a score of power suppliers for use by their meter readers. The object is to have these safety stickers applied on fuse panels. Membership of the Council includes representatives of power suppliers, electric equipment wholesalers and retailers, electrical contractors, manufacturers' representatives, and others interested in electrical applications. The Council's activities are mostly devoted to emphasizing educational efforts among 4-H organizations, vo-ag classes, home-demonstration and home economics classes.

• • •

SAMUEL D. TYSON, a 1952 agricultural engineering graduate, and until recently a sales trainee of Minneapolis-Moline Co., has been promoted by the company to service supervisor with headquarters at Chamblee, Ga.

• • •

EDGAR D. WILBORN recently returned to his native state, Texas, as associate editor of *Progressive Farmer*, where he will work primarily on farm equipment material for the Texas edition. He is a former associate editor of *Farm Implement News* and copywriter with Aubrey, Finlay, Marley and Hodgson, Inc., in Chicago.

• • •

CARROLL E. WORLAN has resigned as extension agricultural engineer, Iowa State College, to accept a position with the Iowa Utilities Assn., 606 Fleming Bldg., Des Moines.

Grass can keep us all "in clover"

Next to pasture, a mow full of good hay rates first with most farmers.

Few feeds are as full of nutritive qualities as hay. Few feeds are so widely used in rations for dairy or beef cattle, hogs, sheep, poultry. And hay is one of the most inexpensive sources of minerals and vitamins—if its quality is high.

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ASAE STANDARDS...RECOMMENDATIONS ...CODES...DATA

The American Society of Agricultural Engineers has in recent years developed and approved several items of reference material, indicated by the above heading, widely used by agricultural engineers, most of which is not available from other sources. This material is made available as printed separates. These separates are printed on tough, heavy paper stock and are punched for filing in 3-ring, loose-leaf binders. The Society also has in stock a quantity of Accopress binders made of a durable grade of black pressboard, specially provided for filing the separates for ready reference, and with the above heading imprinted in yellow letters for easy identification. The separates and Accopress binder can be purchased from the Society headquarters office at prices (postpaid) indicated below for each item. (Any ASAE member may purchase one copy of any separate—not the binder—listed below at one-half the published price.) Quotations on quantity orders of any separate will be furnished on request.

(N.B. All separates listed below are to be included in the contents of the new 1954 *Agricultural Engineers' Yearbook* to be issued annually hereafter by the Society.)

ASAE STANDARD: APPLICATION OF HYDRAULIC REMOTE CONTROL TO FARM TRACTORS AND TRAILING-TYPE FARM IMPLEMENTS. Covers common mounting and clearance dimensions. Eight-page separate. Price per copy 40 cents.

ASAE STANDARD: POWER TAKE-OFF FOR FARM TRACTORS, and ASAE RECOMMENDATION: OPERATING REQUIREMENTS FOR POWER TAKE-OFF DRIVES. The former specifies the essential dimensions of tractor components, while the latter deals with field service factors essential to successful performance of tractor and driven machines. Both included in one four-page separate. Price per copy, 30 cents.

ASAE STANDARD: V-BELT DRIVES FOR FARM MACHINES. Covers application of V-belt, double V-belt, and adjustable-speed-belt drives to farm machines other than tractors. Eight-page separate. Price per copy, 25 cents.

ASAE RECOMMENDATION: FARM TRACTOR AND IMPLEMENT DISK WHEELS. Features mainly provisions for interchangeability in mounting of 20, 18, 16, 15, and 12-inch disk wheels. Eight-page separate. Price per copy, 40 cents.

AMERICAN STANDARD (ROUND HEAD BOLTS): ROUND HEAD SHORT SQUARE NECK BOLT. Extract from an American Standard (ASA B18.5-1952) covering item known in the farm equipment industry as "short square carriage bolt." One-page separate. Price per copy, 20 cents.

ASAE STANDARD: HEADED DRILLED PINS. Intended to reduce the many varieties of headed drilled pins used by farm equipment manufacturers, and to encourage suppliers to stock the type adopted as standard. One-page separate. Price per copy, 20 cents.

ASAE STANDARD: BALING WIRE FOR AUTOMATIC BALERS. Covers specification for annealed baling wire for automatic balers, furnished in 3150 and 6500-foot coils. One-page separate. Price per copy, 20 cents.

ASAE STANDARD: SPECIFICATIONS FOR MARKING PLOWSHARES AND OTHER SOILWORKING SHAPES. Covers specifications for identifying materials used in soilworking shapes. One-page separate. Price per copy, 20 cents.

ASAE RECOMMENDATION: MINIMUM REQUIREMENTS FOR THE DESIGN, INSTALLATION AND PERFORMANCE OF SPRINKLER IRRIGATION EQUIPMENT. Covers basic requirements for the successful operation of sprinkler irrigation systems. Two-page separate. Price per copy, 20 cents.

ASAE DATA: CROP MACHINES USE DATA. Covers draft and power requirements, capacity, cost of use, etc. Eight-page separate. Price per copy, 40 cents.

Accopress binder of tough pressboard for convenient filing of ASAE Standards, Data, and other separates listed above. Price each, 60 cents. (No discount to ASAE members.)

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Pressure-creosoting preserves fence posts in another way, too. Repeated grass fires that often damage untreated posts merely char the surface of pressure-creosoted posts, leaving them unharmed.

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The Performance-Proved Wood Preservative

Applicants for Membership

The following is a list of recent applicants for membership in the American Society of Agricultural Engineers. Members of the Society are urged to send information relative to applicants for consideration of the Council prior to election.

BARNES, NEAL A.—Instructor, North Carolina State College, Raleigh, N. C. (Mail) 2008-B Smallwood Drive

BESCHER, RALPH H. — Manager, technical dept., Koppers Co., Inc., Wood Preserving Div., Orville, Ohio

BRIGGS, CHARLIE P. III — Student experimental engineer, John Deere Dubuque Tractor Works, Dubuque, Iowa

BROSIUS, JOHN W., JR. — Owner, Brosius Engineering & Supply Co., 4 W. Church St., Frederick, Md.

FORD, JAMES M. — Assistant instrument foreman, Heppenstall Co. (Mail) Meadow Green Farm, R R 1, Glenshaw, Pa.

HETZNER, LOWELL E.—Student, Ohio State University. (Mail) Radnor, Ohio

HOLT, JOHN W. — Rural representative, Long Island Lighting Co. (Mail) RFD 1 (12th Ave.), Babylon, L. I., N. Y.

HOOPER, J. M.—Field engineer, The B. F. Goodrich Co., Dept. 6126, Akron, Ohio

JOHNSON, MAURICE V., JR.—Agricultural engineer, Sunkist Field Department Laboratory, 616 E. Grove St., Ontario, Calif.

KONEKE, B. CARL—Agricultural engineer, FAO of the United Nations. (Mail) Government Central Tractor Workshop, Izatnagar, Bareilly, U.P., India

LINDSAY, JACK—Sales engineer, Vancouver Machinery Depot Ltd. (Mail) 1487 20th St., West Vancouver, B.C., Canada

MACKAY, RONALD N.—Sales engineer, Vancouver Engineering. (Mail) 7052 Malibo Drive, North Burnaby, B.C., Canada

ROSENBERGER, STANLEY E.—Assistant vegetable crop specialist, Florida Agricultural Extension Service, University of Florida, Gainesville, Fla.

SMITH, ROBERT A. — District manager, Massey-Harris Co. (Mail) 406 Clayton St., Tupelo, Miss.

TANNER, JOHN S.—Executive vice-president, Servis Equipment Co., PO Box 1590, Dallas, Texas

TEMPLETON, ANDREW R. — Agricultural representative, Monongahela Power Co., Elkins, W. Va. (Mail) 220 Davis Ave.

TERRILL, WILLIAM O.—Field engineer, The Dayton Rubber Co. (Mail) 575 S. Arlington Ave., Elmhurst, Ill.

THOM, LEROY W. — Irrigation engineer, State of Montana. (Mail) Box 526, Deer Lodge, Mont.

THOMPSON, HOWARD A.—Chief engineer, Union Switch and Signal Div., Westinghouse Air Brake Co., 311 West Swissvale Ave., Pittsburgh 18, Pa.

VON STORCH, CARL T.—Buyer and distributor, Pennsylvania Farm Bureau Co-op Assn., Harrisburg, Pa. (Mail) 32 Wilhelm Road

WEITZ, ROBERT J.—Ranch manager, Holmstrom Ranch Co., Box 273, White Sulphur Springs, Mont.

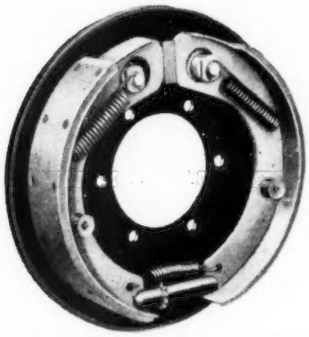
TRANSFER OF MEMBERSHIP GRADE

BONDURANT, BYRON L.—Extension agricultural engineer, University of Delaware, Newark, Del. (Mail) Dept. of Agricultural Engineering. (Associate Member to Member)

COSTEDOAT, LUCIEN — Hydraulic engineer, U.S. Bureau of Reclamation, Fresno, Calif. (Mail) 353 Yosemite Ave. (Affiliate to Associate Member)

STEWART, ROBERT E.—Instructor, University of Missouri, Columbia, Mo. (Mail) 100 Agricultural Engineering Bldg. (Associate Member to Member)

Bendix
Brakes
...designed and built specifically for **Farm Tractors**



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Bendix brakes for farm tractors are specifically engineered for the hard going of field and road work. Tractor manufacturers—as well as automobile and truck manufacturers—look to Bendix as braking headquarters for their industry.

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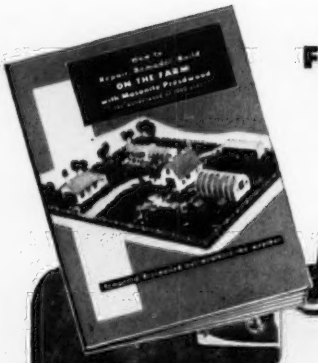
EXPORT SALES:

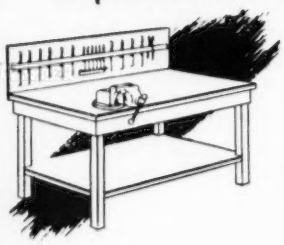
Bendix International Division, 72 Fifth Ave., New York 11, N. Y. • Canadian Sales: Bendix-Eclipse of Canada, Ltd., Windsor, Ontario, Canada



GET THIS FARM FIX-UP BOOK FREE!

Masonite's new book is chock-full of helpful ideas for better farming! You can build any of the low-cost items with ordinary carpentry tools in a few hours of spare time.

Helpful Ideas for better farming!

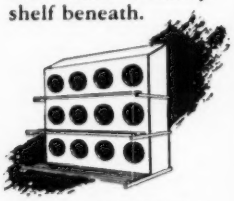


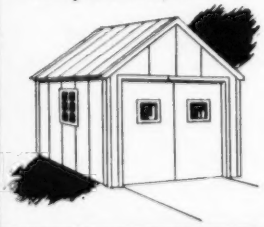
NEW TOP FOR OLD WORKBENCH

Get rid of that splintered, uneven workbench top. Just cut and nail a panel of tough, grainless ¼" Tempered Presdwood over the worn-out surface. Also makes a handy shelf beneath.

12-NEST LAYER

A simple framework covered with Masonite Presdwood panels does the trick in a few hours. Use coping saw to cut circular openings. ½" wooden perches complete the job.



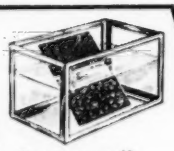


UTILITY BUILDING

Large Masonite Tempered Presdwood panels (4' x 12') go up fast to complete this sturdy all-purpose building. Additional length may be obtained in multiples of 4 feet.

MASONITE® TEMPERED PRESDWOOD® . . .

THE WONDERWOOD OF 1000 USES about the farm. Resists moisture permanently . . . out-weathers the weather! Get acquainted with these large, hardboard panels of wood-made-better. Presdwood will never rot, split, or splinter. Easy to cut, nail and paint.



Test it yourself.
Send for free sample.

MASONITE® CORPORATION
Dept. AE-6 Box 777, Chicago 90, Illinois

"Masonite" signifies that Masonite Corporation is the source of the product

Please send my copy of your Farm Fix-up Book and sample of Tempered Presdwood.

Name.....

Address.....*R.R.*.....

Town.....*County*.....*State*.....

NEW BOOKS

FARM ENGINES AND TRACTORS, by Harold E. Gulvin. Cloth, ix+397 pages, 6 x 9 inches. Illustrated and indexed. McGraw-Hill Book Co. (330 W. 42nd St., New York 36, N. Y.) $6.00.

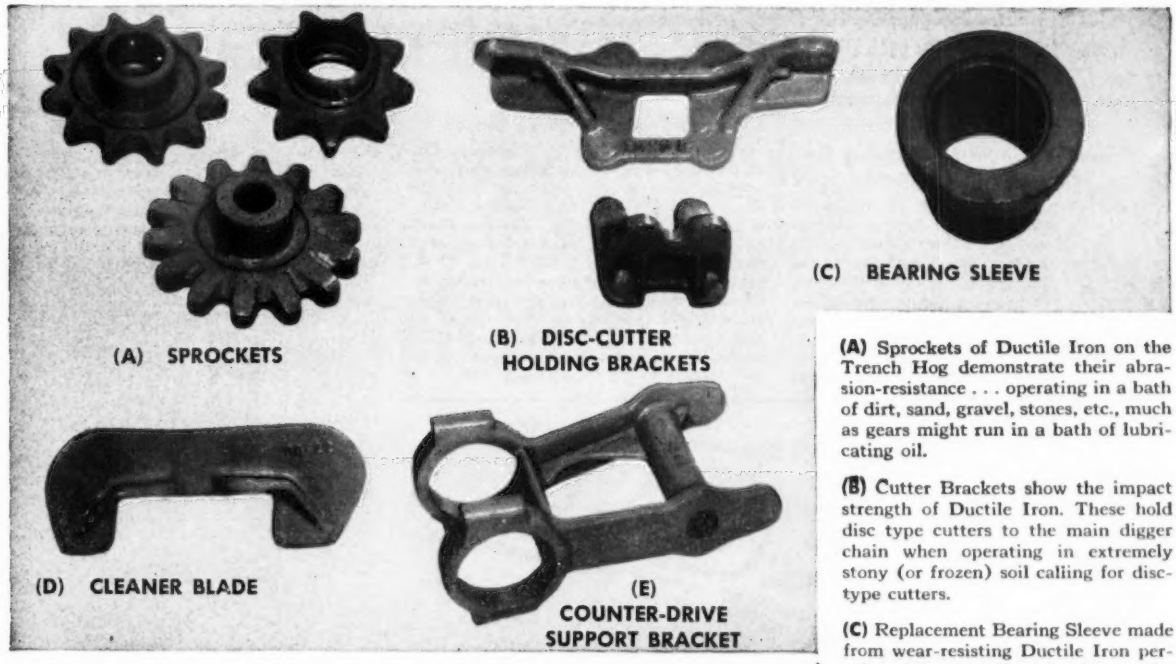
This is an addition to the McGraw-Hill series in agricultural engineering of which Q. C. Ayres is consulting editor. It is intended primarily as a text and reference at the vocational level pointing to sound operation and maintenance procedures which will give maximum service life at minimum repair cost.

MATERIALS OF ENGINEERING, by Herbert F. Moore and Mark B. Moore. Eighth edition. Cloth, ix+372 pages, 6 x 9 inches. Illustrated and indexed. McGraw-Hill Book Co. (330 W. 42nd St., New York 36, N. Y.) $6.00.

A standard engineering text brought up to date to show characteristics of currently available improved materials and progress in engineering methods of using them. Chapters cover cohesion, stress, and strains; the elastic strength of materials; the failure of materials by flow or creep; the failure of materials by fracture; tables of physical properties of typical structural metals; structural damage, working stress, factor of safety; the failure of metallic materials by corrosion and by wear; the production of the common structural metals: cast metals; crystalline structure and heat treatment of metals: alloying; strengthening metal parts by surface treatment, welding, powdered metals; wood; building stone and ceramic materials; cementing materials: gypsum, lime, portland cement, and other hydraulic cements; concrete; plastics; rubber, leather rope; testing and inspection: experimental stress analysis; specifications for materials, and stress, strain, atomic and crystalline distortion, and structural damage to machine parts and structural members.

FARM MANAGEMENT ANALYSIS, by Lawrence A. Bradford and Glenn L. Johnson. Cloth, xii+438 pages, 6 x 9 inches. Illustrated and indexed. John Wiley and Sons, Inc. (440 Fourth Ave., New York 16, N. Y.) $5.75.

College-level text and reference presenting old and new principles of management and their applications to the management of a farm enterprise. Chapters cover (Part 1—orientation) management and its meaning; the subjects which managers must study; management, its functions, and elementary managerial principles; (Part 2—introduction to organizing a farm business) the parts of a farm business and income statements; the approach to farm organization and reorganization; capital limitations, capacities and goals or objectives; farm selection and evaluation of the farm resource; the need for economizing principles in developing crop and livestock systems; multiple production relationships in farming; how many enterprises; cost of production concepts and farm management; fitting crops into a crops program; the use of livestock; "roughing out" a livestock program for a specific farm; input-output relationships in pork production; input-output relationships in dairy production; input-output relationships in beef production; labor and working capital; prices for use in budgeting; (Part 3 operating a farm business) principles for increasing the efficiency with which the managerial tasks are performed; uses of managerial principles in farm operation illustrated; getting and using resources; farm and home planning; some miscellaneous conceptual problems involving management.



(A) Sprockets of Ductile Iron on the Trench Hog demonstrate their abrasion-resistance . . . operating in a bath of dirt, sand, gravel, stones, etc., much as gears might run in a bath of lubricating oil.

(B) Cutter Brackets show the impact strength of Ductile Iron. These hold disc type cutters to the main digger chain when operating in extremely stony (or frozen) soil calling for disc-type cutters.

(C) Replacement Bearing Sleeve made from wear-resisting Ductile Iron permits minimum wall section because its strength is much higher than that of gray iron, although it has the same machinability rating.

(D) Cleaner Blades of Ductile Iron mounted at regular intervals on the digger chain withstand battering and abrasion by stones and soil. These parts also prove the impact resistance of Ductile Iron.

(E) Counter-drive Support Brackets are subject to twisting action. Ductile Iron makes possible smaller, lighter brackets . . . with a higher safety factor against breakage.

Test DUCTILE IRON on Your Tough Jobs for a "SHOWDOWN" PROOF of its

- **Resistance to Wear**
- **Resistance to Impact**
- **High Strength**
- **Superior Machinability**

Only actual use can demonstrate the remarkable properties of Ductile Iron.

For Ductile Iron combines the *process advantages* of cast iron . . . such as good castability, ready machinability and moderate cost . . . with many of the *product advantages* of steel.

Several times stronger than ordinary cast iron, Ductile Iron also offers greatly increased shock resistance and ductility. As an example of some of Ductile Iron's many useful applications, look at the parts produced by STATE FOUNDRY AND MACHINE COMPANY, Cedar Grove, Wisconsin, for use on the Trench Hog digger manufactured by ARPS CORPORATION, New Holstein, Wisconsin.

Send us details of your prospective uses, so that we may offer a list of sources from some 100 authorized foundries now producing Ductile Iron under patent licenses. Request a list of available publications on Ductile Iron . . . mail the coupon now.

The International Nickel Company, Inc.
Dept. 20, 67 Wall Street, New York 5, N. Y.

Please send me a
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THE INTERNATIONAL NICKEL COMPANY, INC. 67 WALL STREET NEW YORK 5, N. Y

NEWS FROM ADVERTISERS

New Products and Literature Announced by AGRICULTURAL ENGINEERING Advertisers

Power Transmission Catalog for Machinery Designers

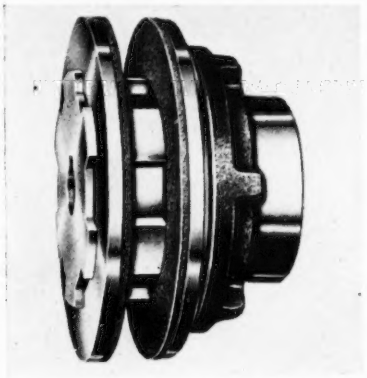
Chain Belt Co., Dept. P.R., Milwaukee 1, Wis., will send on request Bulletin No. 53-110, as "Abbreviated Catalog" on Rex cast and steel chain, cast tooth sprockets, belt conveyor idlers and spray nozzles, which has just been released by the company. It is intended for designers of equipment using sprocket chains and power transmission machinery, as well as purchasers of this material. This 56-page book has a pictorial index on the inside front cover. Chain listings and prices are given along with sprocket information. Take-ups, buckets, idlers, spray nozzles, and chain attachments are also listed.

Heat Transfer House Organ

Young Radiator Co., 709 S. Marquette St., Racine, Wis., will without charge, place interested engineers on the mailing list of its new house organ, "Young Heat Transfer News," to be published bi-monthly. Requests should be addressed to Editor, "Heat Transfer News," in care of the company. The purpose of the publication is to disseminate engineering information on existing and new installations. Subjects of installations include pictorial and editorial presentations of aeronautical, automotive, oil field, heavy industrial, municipal and chemical process cooling equipment.

Adjustable Torque-Limiting Clutches

Morse Chain Co., 7601 Central Ave., Detroit 10, Mich., announces a new line of adjustable torque-limiting clutches that provide overload protection for machine drives in a wide variety of equipment. These slip-type friction clutches act as automatic shear-pin mechanisms and avoid the time and labor required to insert new shear pins. They are adapted to roller-chain drives and are designed



The new Morse torque-limiting clutch

to be used in connection with standard Morse Type A plain plate roller chain sprockets. Other types of rotating members such as gears, pulleys and sheaves can also be used with the new clutches. The clutches consist of a steel body, two steel clutch plates, two friction disks, a Belleville clutch spring and a cast-iron adjusting nut. The rotating member is held between the friction disks through spring pressure exerted on the clutch plates that slide on splines on the hub. The torque setting of the clutch is obtained by adjusting the spring tension with the threaded thumb nut. These clutches are made in 4½, 5½ and 6½-in-diameter sizes with ratings of 55, 121.5 and 260 ft-lb, respectively.

New Six-Cylinder Diesel Tractor

J. I. Case Co., Racine, Wis., announces its new Model 500, 6-cylinder engine, all-diesel tractor. It is estimated to be in the 60-belt horsepower range and will pull a 5-bottom plow under most conditions. Starting on diesel fuel is accomplished by a 12-v electric starting system using two large 6-v batteries in series.

The new Case Model 500 diesel tractor

Normally the engine is started by opening the throttle and pressing the starter button. At six separate points the tractor is guarded from the main cause of diesel troubles, dirt in the fuel. Besides three stages of filtering, one cleanable and two renewable, there is a cleanable filter on the fuel tank vent, a deep filler-hole screen, and a water trap. A single-plunger injection pump feeds all six cylinders successively through a distributor. Power steering is available as factory equipment.

(Continued on page 572)

WISCONSIN

The Name that Stands for

HEAVY-DUTY Air-Cooled ENGINE POWER at its Best!

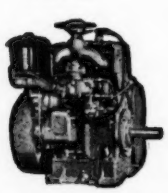
More than 500 manufacturers of engine-powered equipment of all kinds, including many time- and labor-saving machines designed for most efficient, dependable farm service, specify WISCONSIN Heavy-Duty Air-Cooled Engines as "original equipment".

These machinery builders base their selections of engines on such factors as heavy-duty construction, low-cost operation and maintenance, Air-Cooling that provides trouble-free service in all locations, easy starting, and readily available replacement parts when needed, through a reliable source.

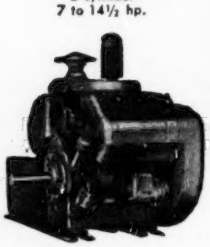
Wisconsin Motor Corporation is the world's largest manufacturer of Heavy-Duty, Air-Cooled Engines, from 3 to 36 horsepower, in 4-cycle single-cylinder, 2- and 4-cylinder types.

These engines have been used successfully for many years on combines, balers, elevators, water pumps, hammer mills, garden tractors and many other farm power applications. Here is dependable power to fit the machine and fit the work for which the machine is designed. Complete your power data file by writing for information today.

4-cycle single-cylinder 3 to 9 hp.



2-cylinder 7 to 14½ hp.



V-type 4-cylinder 15 to 36 hp.

WISCONSIN MOTOR CORPORATION

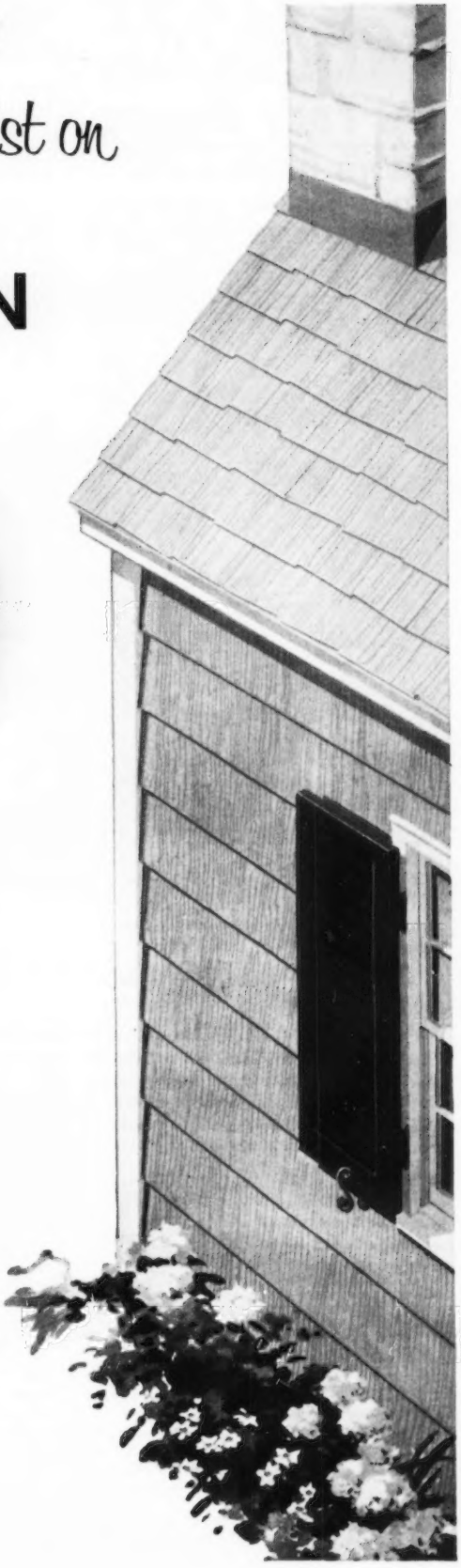
World's Largest Builders of Heavy-Duty Air-Cooled Engines

MILWAUKEE 46, WISCONSIN

A 7516-½-A-I

ASBESTOS SIDING?

3 reasons why you should insist on Johns-Manville SMOOTHGRAIN



1 Superior Styling . . .

Viewed from any angle, Smoothgrain has a rich, grained texture, yet its surface is smooth and resistant to soiling. Colors are beautifully styled in deep autumn shades or smart springtime pastels. The pleasing grained texture and lasting colors are achieved by colored ceramic granules deeply embedded in the asbestos cement siding.

2 Outstanding Quality . . .

The J-M manufacturing process gives Smoothgrain Siding dimensional stability—resistance to shrinking—tight joints that won't open up later on. Furthermore, the built-in texture is so striking, that you can hardly see face nails and vertical joints.

3 Best Known Name . . .

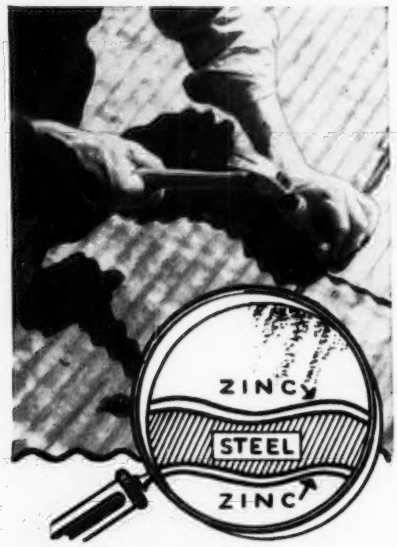
The Johns-Manville name has been the standard of quality for 95 years. Color ads in national magazines and the Bill Henry Radio News Program are constantly building preference for products which carry the J-M name.

For full information **about Smoothgrain Asbestos Siding and other J-M Building products, write Johns-Manville, Box 60, New York 16, N. Y.**

JOHNS-MANVILLE JM PRODUCTS **Johns-Manville**

Get MORE for Your Money

WITH GALVANIZED ROOFING and SIDING!



STRENGTH OF STEEL adds structural rigidity to farm buildings. Takes the hard knocks and rough treatment.

RUST RESISTANCE OF ZINC! It's the zinc that stops the rust. Get the heaviest zinc coating you can buy. Authorities agree that the heavier the zinc coating, the longer the rust-free service.

STAYABILITY — Galvanized sheets *stay put* as only galvanized sheets can. They hold at the nail holes.

TIME-TESTED ECONOMY — More than ⅓ of all farm buildings in the U. S. are covered by galvanized roofing. Get galvanized sheets for long, trouble-free service, and for—

SUPER SERVICE
get the SUPER SHEET
bearing this "Seal of Quality," signifying at least 2 ounces of zinc per square foot.

ZINC INSTITUTE 2 OZ. COATING SEAL OF QUALITY

FREE . . . INSTRUCTION MANUALS

WRITE: AMERICAN ZINC INSTITUTE
324 Ferry Street, Rm.
Lafayette, Indiana

- ☐ Facts about Galvanized Sheets
- ☐ Directions for Laying Galvanized Sheets
- ☐ Metallic Zinc Paint Protects Metal Surfaces

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Address_____

City_____

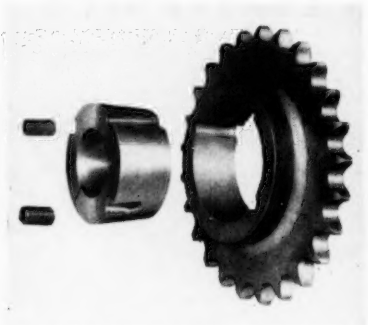
NEWS FROM ADVERTISERS

(Continued from page 570)

Roller Chain Sprocket Wheels with Taper Lock Bushings

Link-Belt Co., 307 N. Michigan Ave., Chicago 1, Ill., announces a new line of roller-chain sprocket wheels with taper-lock bushings.

Without reboring, stock sizes of sprocket wheels can be securely mounted on a shaft, equivalent to a shrink fit. Action of the taper-lock bushing assures tight fit within the full range of normal shafting tolerances. Setscrews force and hold the split tapered bushing in the



Link-Belt roller chain sprocket wheel with taper-lock bushing

tapered bore of the sprocket wheel causing it to lock tightly onto the shaft. The full length of the bushing supports the sprocket on the shaft. Assembly and disassembly are easy.

Link-Belt sprocket wheels with taper-lock bushings for ½, ⅝, ¾, 1 and 1¼-inch pitch single-width chains are now available from Link-Belt Co. A 16-page book, No. 2449, just published by the company, giving detailed information about these sprocket wheels will be sent on request to interested readers.

A New Row-Crop Tractor

Deere and Co., Moline, Ill., now has in production the Model 70, tricycle-type, row-crop tractor, successor to its Model G. It is rated to develop up to 50.35 hp at the belt pulley and 44.21 hp on the drawbar, under specified standard conditions, when equipped

The Deere Model 70 row-crop tractor

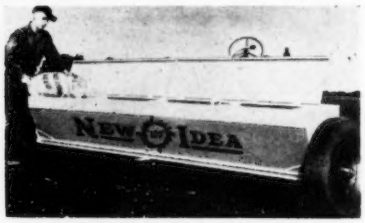
with the gasoline engine. The all-fuel engine is optional at no extra cost. In any case it is a four-plow size embodying features user-tested on Models 50 and 60. These features include duplex carburetion, live PTO shaft, live hydraulic power control, light hydraulic remote cylinder, quick-change wheel tread, two-piece front-wheel pedestal and matched high-capacity operating equipment.

Data Sheet on Friction Clutches

Morse Chain Co., 7601 Central Ave., Detroit 10, Mich., will send readers on request an illustrated engineering data sheet (Form S31-53) describing the new line of Morse torque-limiting slip-type friction clutches which provide overload protection for a variety of machine drives by functioning as an automatic shear-pin mechanism. The data sheet, which is punched for a 3-ring binder, includes dimensions and capacities of standard 4½, 5½ and 6½-in-diameter adjustable clutches. Tables of specifications of standard Morse Type A plain plate roller chain sprockets that can be used in connection with the compact torque-limiting clutches are also included.

New Fertilizer Spreader

The New Idea Division, Avco Mfg. Corp., Coldwater, Ohio, has introduced a new fertilizer spreader which is available in three pull-type models—8, 10, or 12-ft spreading widths —which spread from 10 to 5,000 lb per acre.



New Idea pull-type spreader

It has a patented positive-control rate dial which can be set according to the rate needed per acre and also according to the kind of fertilizer or seed. Other features include a strong, tractor seat control lever, a heavy-gauge steel all-welded hopper and quick-removable shutters. Its patented cam agitator is designed to grind, sift, level, mix and force any spreadable material evenly through port openings. A grass seeder attachment is also available.

New, Large Portable Elevator

Deere and Co., Moline, Ill., announces the new portable John Deere 18½-in-wide elevator available in lengths of from 26 to 50 ft, capable of handling all crops, including 16 by

The Deere large portable loader

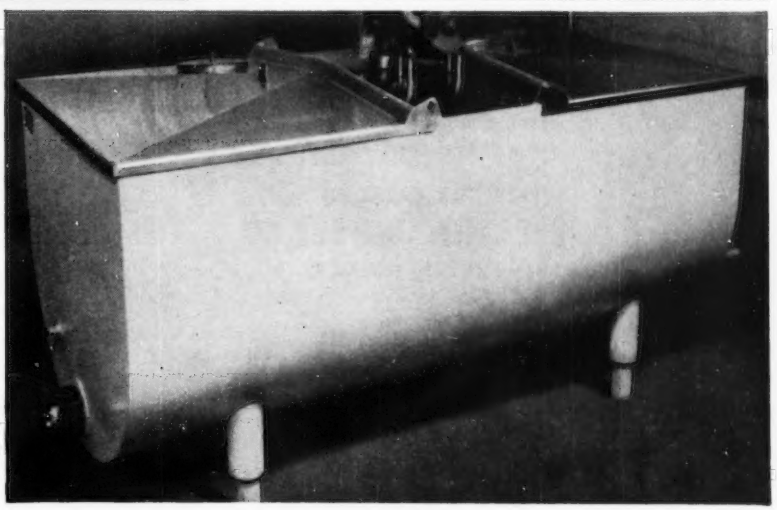
18-in bales lying flat. An adjustable bale chute extends up to the hayrack bed for feeding of the bales up the bridge-trussed elevator. Large capacity hoppers for handling ear or shelled corn and small grains are available for regular and wide bed wagons and trucks. The main drives on both the hopper and elevator are protected by slip clutches.

TAKE A TIP FROM THIS PRODUCER:

"We are producing better quality milk with our Stainless Steel bulk storage tank"

says Ainsworth Sondericker

WILLIAM SONDERICKER (left) and his son, Ainsworth Sondericker, are thoroughly sold on the many advantages of tanker pickups from their Stainless Steel cooling and holding tank.



THIS 200-GALLON Stainless Steel tank on the Sondericker farm cools milk from 20 cows and holds it for every other day pick-up. The Sondericker produce for Dairymen's League Co-operative Association, Inc., Buffalo, New York.

● Working with the Dairymen's League of Western New York, 15 farmers in the vicinity of Attica, N. Y. installed Stainless Steel bulk milk tanks a year ago, making possible tanker pickup of the milk they produce.

Ainsworth Sondericker, who, with his father, William Sondericker, operates a 250-acre dairy farm, reports on his first year of operation:

"Our returns are higher because we are producing a better quality of milk. Faster cooling means less bacteria growth and resulting off flavor. A better tasting milk means more will be sold for drinking, thus insuring a better return.

"For three successive years we received an award for not having more than one bacteria count in excess of 100,000 for each year. Since using the bulk tank, our counts have been lowered to around 7,000."

When you change to the bulk handling system with a Stainless Steel farm tank, important savings in time and labor go hand in hand with better quality milk. Clean-ups are always quick and easy and heavy lifting and handling is a thing of the past.

If you are interested in a bulk handling system using Stainless Steel tanks, we will be glad to supply you with information which we have acquired in working with our customers who manufacture Stainless Steel farm tanks. Just mail the coupon below; no obligation, of course.

UNITED STATES STEEL CORPORATION, PITTSBURGH • AMERICAN STEEL & WIRE DIVISION, CLEVELAND
COLUMBIA-GENEVA STEEL DIVISION, SAN FRANCISCO • NATIONAL TUBE DIVISION, PITTSBURGH
TENNESSEE COAL & IRON DIVISION, FAIRFIELD, ALA.
UNITED STATES STEEL SUPPLY DIVISION, WAREHOUSE DISTRIBUTORS
UNITED STATES STEEL EXPORT COMPANY, NEW YORK

U·S·S STAINLESS STEEL

SHEETS · STRIP · PLATES · BARS · BILLETS
PIPE · TUBES · WIRE · SPECIAL SECTIONS

Agricultural Extension Section
United States Steel Corporation, Room 2814-H
525 William Penn Place, Pittsburgh 30, Pa.

Please send me free literature about farm bulk milk equipment. Send information to:

Name .....
Title .....
Company .....
Street .....
City ..... Postal Zone ..... State .....

United States Steel is a steel producer, not a bulk milk equipment fabricator. Your request, therefore, will be sent to manufacturers who fabricate bulk milk equipment for farm use.

3-1444-A

UNITED STATES STEEL

FOR FARM AND INDUSTRY

ELECTRIC

WHEELS ARE RIGHT

Over 65 years in wheel manufacturing have given us the "know how"—modern production methods assure long life and efficient wheel performance in the field.

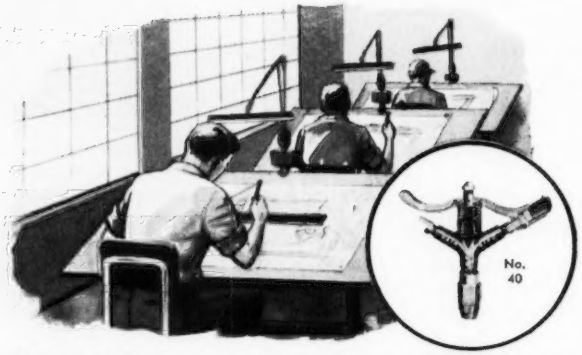
There is an ELECTRIC spoke or disc wheel for most types of portable equipment. Axles are available where required.

Our experienced engineers are ready to assist you in solving your wheel and axle problems and we will offer our recommendations upon receipt of your specifications.

WRITE FOR CATALOG

ELECTRIC WHEEL CO.

2811 CHERRY, QUINCY, ILL.



Specific Irrigation Requirements

Endorsing fully the code adopted by the ASAE for portable sprinkler irrigation installations, National Rain Bird Sales & Engineering Corp. began years ago to plan irrigation systems to meet *specific requirements*. These plans are worked out on the engineer's drafting board and are based on definite field information.

When we say "Consult our Research and Planning Department," it means that qualified irrigation engineers give each requirement expert advice and plans that work. Remember, there's a Rain Bird Sprinkler to answer every irrigation problem.

S.I.A.
Member of
Sprinkler Irrigation Association

NATIONAL
RAIN BIRD SALES & ENGINEERING CORP.
AZUSA, CALIFORNIA
RAINY SPRINKLER SALES
1633 WEST LAKE ST., PEORIA 5, ILLINOIS

SURPLUS AND SHORTAGE SERVICE

EDITOR'S NOTE: It is estimated that 90 percent or more of the available literature on agricultural engineering of value as authoritative reference material is to be found in the volumes of AGRICULTURAL ENGINEERING. This is why more and more agricultural engineers are giving special attention to maintaining complete files of this publication. To this end, we are offering a special service to ASAE members and others. If you have need of back issues (or complete volumes) for your reference files, send us a list of them and we will publish it in this column.

If you have surplus copies or volumes you are willing to dispose of, send us a list and indicate the unit price (postpaid) you will accept for them, and also whether you will sell the lot as a whole or separately. Address AGRICULTURAL ENGINEERING, Surplus and Shortage Service, St. Joseph, Michigan.

* * *

Agricultural Engineering Dept., University of New Hampshire, Durham, is in need of a copy of AE for April, 1925 (no. 4, vol. 6), the only copy missing from the University library.

An ASAE member has sent the editor the following copies of AE which he offers for sale at 20 cents each postpaid: 1948—Oct, Nov, Dec; 1949—Jan, Feb, Mar, Apr, May, Jun, Sep, Oct, Nov, Dec; 1950—Jan, Feb, Apr, May, Oct, Dec; 1951—Jan, Sep, Nov, Dec; 1952—Mar, Apr, Jun, Jul, Aug, Oct. (Mention HAJ copies when ordering from this list.)

Frank G. Mackaness has shipped the editor the following copies of back issues of AE: Oct, Nov, and Dec, 1945; Jun, Jul, Aug, Sep, Oct, Nov, and Dec, 1949; Jan, Mar, Apr, Jul, Aug, and Sep, 1950. These copies will be mailed, so long as they last, at a price of 10 cents per copy to cover postage and handling. (Mention FGM copies when ordering from this list.)

A. B. Skromme, John Deere Ottumwa Works, Ottumwa, Iowa, would like to trade in 25 surplus copies of AE (at 30 cents per copy postpaid) plus some cash to buy 39 copies of which he is short. *Surplus copies:* 1934—Oct, Dec; 1935—Jun, Dec; 1936—Sep; 1937—Jun, Jul, Aug, Sep, Oct, Nov; 1938—Mar, Jun, Jul, Aug, Sep, Oct, Nov; 1939—Jan, Feb, Mar, Apr, May, Sep, Nov. *Copies needed:* 1930, Aug; 1931, Nov; 1934, Nov; 1936, Jan; 1937, Jan, May; 1939, Oct; 1940, Jan, Dec; 1941, Jan, Feb, Mar, Apr, May, Jun, Dec; 1942, Mar, Dec; 1943, May; 1944, Jan, Mar; 1945, Dec; 1946, Jan, Feb, Apr; 1947, Apr, Jun, Aug; 1950, Mar.

J. E. Nicholas, agricultural engineering dept., Pennsylvania State College, State College, has certain number of surplus copies he will dispose of, and he is in need of a considerable number to complete his personal file, which will ultimately be donated to the departmental library; they are as follows: *Surplus copies:* 1925, Oct; 1930, Jan; 1932, Sep; 1940, Jun (2); 1941, Feb, Jul (3), Dec (2); 1942, Feb, Jul; 1944, Oct (2); 1946, May (2); 1948, Apr; 1949, Jun; 1950, Jul; 1951, Feb. *Copies needed:* 1925, Jan, Sep, Dec; 1926, Jan, Dec; 1927—all except Oct; 1928, Jan, Dec; 1929—all except Feb and Mar; 1930—all except Jan and Jul; 1931, Jan, Dec; 1932, Jan, Jun, Aug, Oct; 1934, Mar, Nov; 1935, Dec; 1937, Jan, Dec; 1943, Jul, Dec; 1946, Feb; 1947, Mar; 1949, Feb; 1950, Mar, Nov, Dec; 1951, Jan; 1952, Oct.

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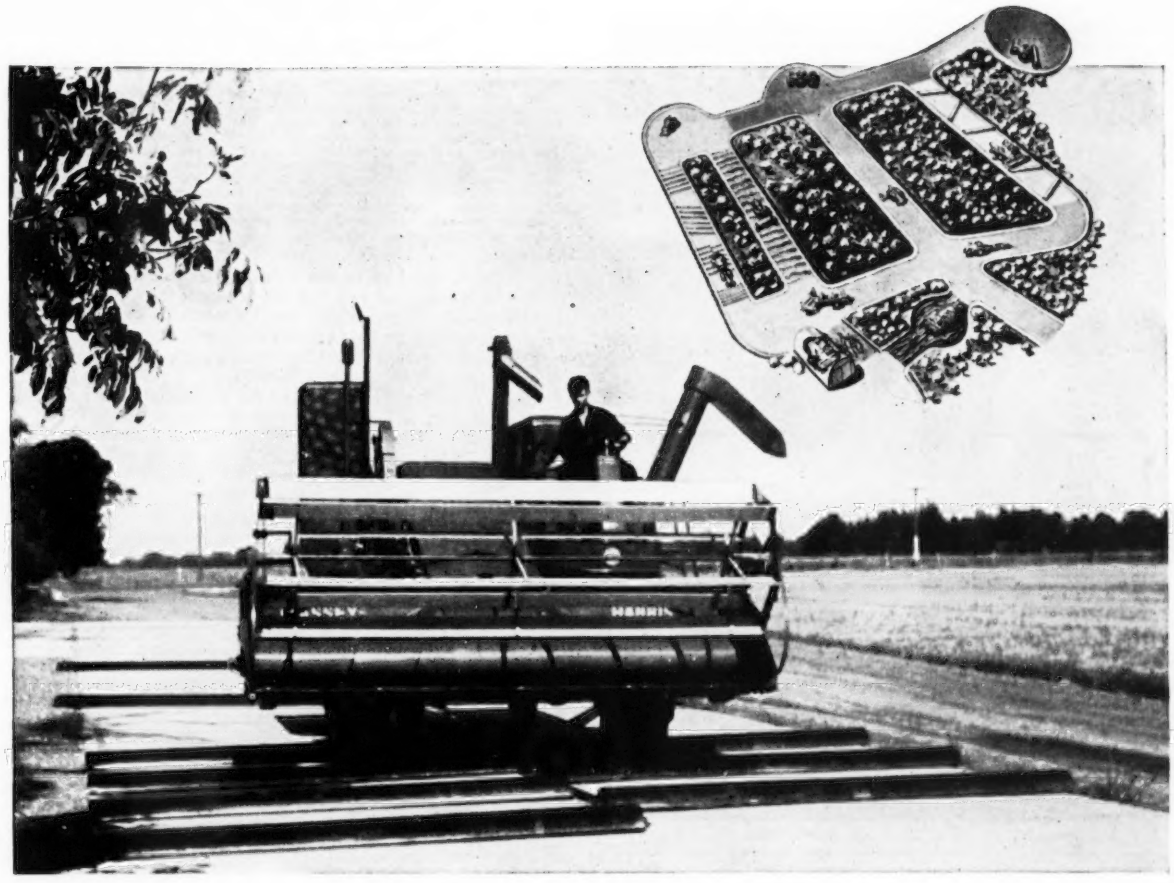

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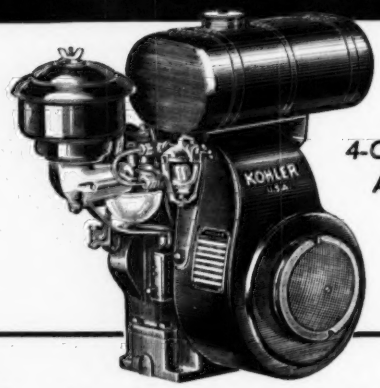

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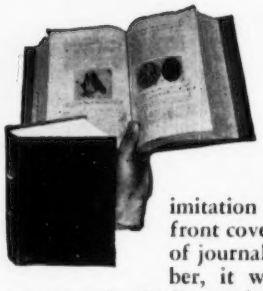

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Personnel Service Bulletin

The American Society of Agricultural Engineers conducts a Personnel Service at its headquarters office in St. Joseph, Michigan, as a clearing house (not a placement bureau) for putting agricultural engineers seeking employment or change of employment in touch with possible employers of their services, and vice versa. The service is rendered without charge, and information on how to use it will be furnished by the Society. The Society does not investigate or guarantee the representations made by parties listed. This bulletin contains the active listing of "Positions Open" and "Positions Wanted" on file at the Society's office, and information on each in the form of separate mimeographed sheets, may be had on request. "Agricultural Engineer" as used in these listings, is not intended to imply any specific level of proficiency, or registration, or license as a professional engineer.

NOTE: In this bulletin the following listings still current and previously reported are not repeated in detail; for further information see the issue of AGRICULTURAL ENGINEERING indicated.

POSITIONS OPEN — MARCH—O-99-509. MAY—O-140-516, 182-518, 190-519. JUNE—O-206-521, 208-522, 147-524. JULY—O-240-525, 254-526, 255-527, 270-528.

POSITIONS WANTED—JANUARY—W-827-152, 884-154, 896-157. FEBRUARY—W-21-5, 19-6, 26-7, 27-8. MARCH—W-29-9, 56-10, 79-15, 85-16, 68-17. APRIL—W-64-19, 80-20. MAY—W-120-23, 109-25, 162-26, 163-27, 151-28, 169-29, 192-30, 193-31, 196-32. JUNE—W-204-34, 205-35, 200-36, 203-37, 210-38, 215-39, 220-40. JULY—W-231-41, 260-42, 266-43.

NEW POSITIONS WANTED

AGRICULTURAL ENGINEER for design, development, management, sales or service in the irrigation field, with equipment manufacturing concern, farm management company, or farming operation. Prefer West Coast or Rocky Mountain area. BS deg in agricultural engineering, University of Nebraska, 1950. Agricultural engineer, Soil Conservation Service, 3½ yr. Experience with pump irrigation and pumping equipment. Area engineer for conservation structures in 6 counties. Ability to cooperate with fellow employees. Farm background. Married. Age 27. Limited vision in right eye. 60 days notice. Salary $5500. W-269-44

AGRICULTURAL ENGINEER for design, development, research, extension, or teaching in farm structures, rural electric, or soil and water field, with industry or public service. Midwest preferred. BS deg in agricultural engineering 1948, University of Illinois. Experience in drainage and soil conservation work with state department of agriculture 1½ yr. With USDA in crop storage research one year. Commissioned service in Army Corps of Engineers 1½ yr. Married. Age 29. Vision corrected by glasses. Available on 30-day notice. Salary $4500. W-248-45

AGRICULTURAL ENGINEER for extension, teaching, research, or writing, soil and water field, industry or public service, any location. BS and MS deg in agricultural engineering, 1949 and 1952, University of Tennessee. Farm background. Engineering and farm planning with SCS 17 mo.; teaching soil and water and farm machinery, University of Tennessee, 15 mo. Hydrologic engineer with TVA, 18 mo. War enlisted service in Air Force 3½ yr. Married. Age 31. No disability. Available now. Salary open. W-272-46

AGRICULTURAL ENGINEER for design, development, sales, service or writing, power and machinery field, private industry. Midwest preferred. BS deg in agricultural engineering, Iowa State College, 1942. Draftsman in engineering department of farm equipment manufacturer, one year. War service with Air Force 4 yr, aviation cadet and commissioned. Materials handling engineer with farm equipment manufacturer, 4 yr. Recalled to active duty with Air Force one year. Returned to farm equipment manufacturer November 1952 and promoted to assistant superintendent of material handling and storekeeping. Married. Age 33. No disability. Available September 1. Salary $7,500. W-234-47

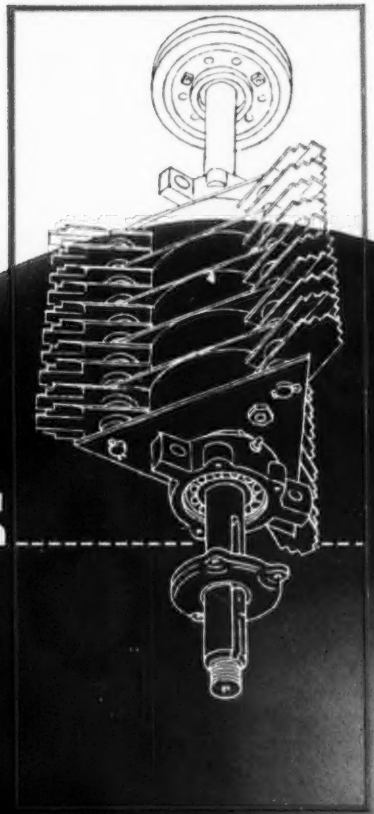
AGRICULTURAL ENGINEER for teaching, research, design, development, or management. Soil and water or power and machinery. Major interest in irrigation. Southwest preferred. MS deg in agricultural engineering, 1947, Texas A. & M. College. Irrigation engineer (awaiting approval of thesis), 1952, Utah State Agricultural College. Teaching 4 yr, including 2 yr as head of agricultural engineering department. War commissioned service in Navy 4 yr. Agricultural engineer 2 yr and assistant director for Brazil, one year, American International Association. Teaching and other engineering work part time along with graduate study. Registered professional engineer, New Mexico. Federal Civil Service rating GS-13 as agricultural administrator, hydraulic engineer, irrigation engineer, and irrigation specialist. Married. Age 35. No disability. Available now. Salary open. W-288-48

AGRICULTURAL ENGINEER for sales, service, writing, management, or farm appraisal with manufacturer or farming operation in West. Limited travel. BS deg in agricultural engineering, University of California, 1950. Farm appraiser 3 yr. Highway survey work 6 mo. Park ranger 3 mo. Credit report writer 2½ yr. War commissioned service in Air Force as navigator, 3 yr. Married. Age 32. No disability. Available in October or November. Salary open. W-278-49

AGRICULTURAL ENGINEER for design, development, sales or service in soil and water field, especially irrigation, with manufacturer or distributor. Any location. BS deg in agricultural engineering, 1950, University of Minnesota. Sales engineer 3 yr with water supply equipment distributor, including work on design, sales and service of filter plants, pumps and portable irrigation systems. Farm background. War enlisted service in Navy 14 mo. Married. Age 26. No disability. Available on reasonable notice. Salary $450 mo. W-292-50

AGRICULTURAL ENGINEER for research and development in power and machinery with industry or public service. Any location. BS deg in mechanical engineering and in agriculture, 1949, University of Wisconsin. Over 4 yr in design, development, and field testing of forage harvesting equipment and storage mediums for chopped forage, with leading manufacturer. War service with Army Air Corps, 43 mo. Married. Age 30. No disability. Available on reasonable notice. Salary open. W-281-51

AGRICULTURAL ENGINEER for design, development, or management in soil and water or product processing with industry or public service, any location. Willing to travel. BS deg in agricultural engineering, 1949, University of Nebraska. Farm background. District engineer 3 yr, SCS. Irrigation engineer and farm manager on 40,000-acre farm one year. Irrigation engineer on same farm 3 mo. War service 2 yr as naval aviation cadet. Married. Age 28. No disability. Available on 30-day notice. Salary open. W-294-52



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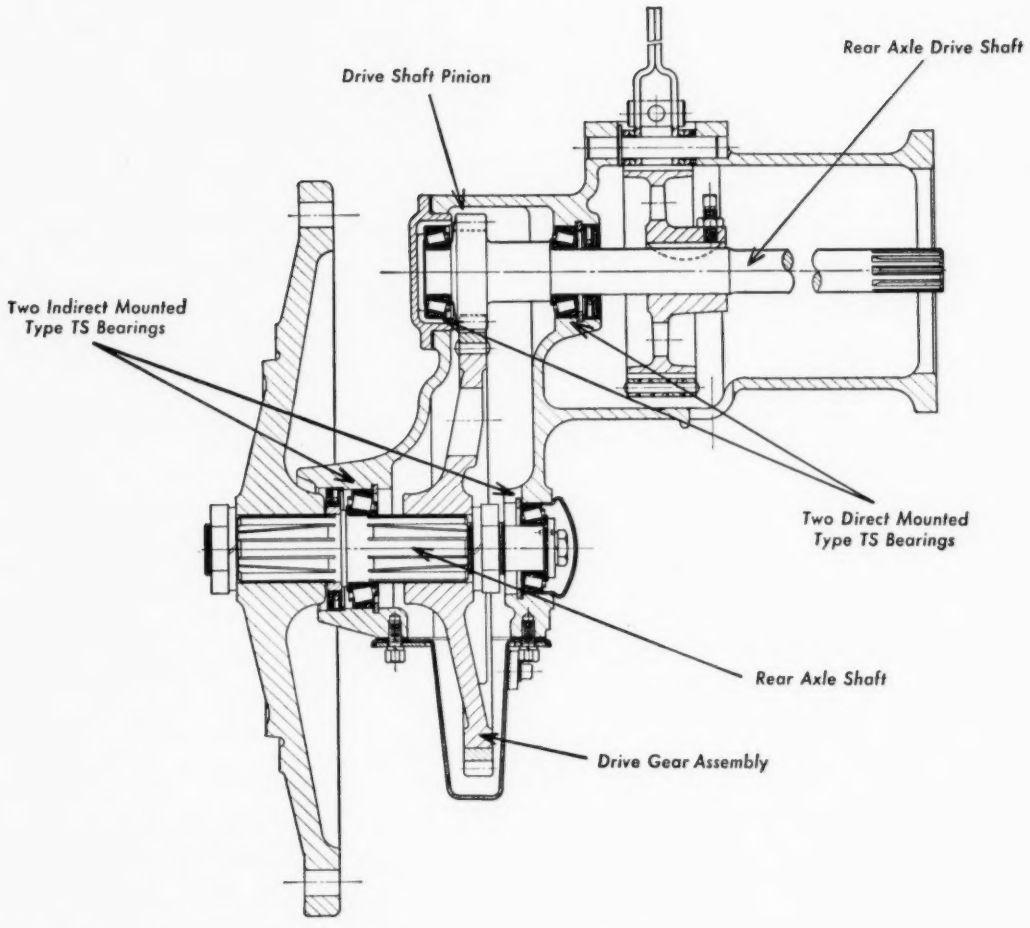
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